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The Journal of Bone and Joint Surgery*

The Official Publication of the American Orthopaedic Association and of the British Orthopaedic Association

* Title registered in United States Patent Office

VOL. XV, No. 1 — *January, 1933* — Old Series VOL. XXXI, No. 1

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Published Quarterly: January, April, July, and October
8 THE FENWAY, BOSTON, MASSACHUSETTS

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Address all Communications to the Editor

THE JOURNAL OF BONE AND JOINT SURGERY

8 The Fenway, Boston, Massachusetts, U. S. A.

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The Journal of Bone and Joint Surgery

OPERATIVE ARRESTMENT OF LONGITUDINAL GROWTH OF BONES IN THE TREATMENT OF DEFORMITIES *

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Inequality in length of the extremities during the growing period may result from a variety of causes. Among these are:

1. Fractures with overriding of fragments or obliteration of an epiphyseal line.

2. Joint infections with destruction of an adjacent epiphysis. This results in shortening and is seen especially in the upper end of the femur as a result of tuberculous or pyogenic infection of the hip. Tuberculous arthritis of the knee may produce excessive longitudinal growth, but rarely of an amount that results in a noticeable deformity.

3. Bone infections. They may result in shortening either from partial or complete obliteration of an epiphyseal line or from destruction of a segment of the shaft of a bone. Occasionally lengthening from excessive regional overgrowth of bones is due to extensive pyogenic osteomyelitis. Thus, in case of osteomyelitis of the femur the involved extremity may be as much as one or two inches longer than the normal one due to overgrowth, not only of the femur but also of the tibia and fibula. Speed[1] has reported such cases. Osteomyelitis variolosa may produce shortening of one to several bones from obliteration of epiphyseal lines as reported by Brown and Brown.[2]

4. Bone tumors arising in connection with the ends of the shafts of growing long bones. These are nearly always either enchondromata or exostoses. Enchondroma may be single or multiple. The condition of multiple enchondroma affecting a number of bones in one or more extremities which was designated by Ollier as dyschondroplasia nearly always results in shortening and often in curvature or angulation of the involved limb. Single enchondroma resulting in shortening is most frequently seen in the lower end of the ulna. Multiple cartilaginous exostoses result in less marked shortening than multiple chondroma, but there is almost

* Presented at the Annual Meeting of the American Orthopaedic Association, Toronto, June 18, 1932.

constantly some shortening of both ulna and fibula and it may be of marked degree in the ulna. The short ulna results in ulnar deviation of the hand and bowing of the radius, and sometimes dislocation of its head. The short fibula results in lateral subluxation of the astragalus and eversion of the ankle. Single exostosis rarely results in shortening. Arrestment or retardation of longitudinal growth is rarely produced by other types of tumors or by solitary bone cyst. Regional fibrocystic disease may make shortening, but more from fracture with bowing than from retardation of growth.

5. Congenital disturbances may result in either shortening or lengthening of the bones of the extremity. Local or regional giant growth and von Recklinghausen's neurofibromatosis are occasional causes of abnormal lengthening of bones of the extremities. Congenital absence of one or both epiphyses or occasionally of an entire bone may be the cause of marked shortening in either the upper or lower extremity. Arteriovenous aneurysms in children, which are nearly always congenital, usually result in lengthening of the affected limb as illustrated by the report of twenty-three cases by Horton[3], with lengthening in eighteen.

6. Infantile paralysis affecting markedly one lower extremity with the other either normal or only slightly involved usually retards growth so that there is considerable difference in the length of the limbs.

Arrest or retardation of longitudinal growth on one side only of the epiphyseal line results not only in shortening but also in angulation, due to continued although lessened growth on the other side.

It is a long established fact that all longitudinal growth of the shafts of bones of the extremities takes place through the cartilaginous epiphyseal lines. The recent experiments of Gatewood and Mullen[4] proved that this is so, even when the epiphyseal lines are fused during the growing period. They found that there was no compensatory lengthening of the growing shaft of the femur, whose lower epiphysis was fused with the shaft at a comparatively early age.

The extent of inequality of length varies greatly with the cause and the length of time that the causative agent was active. Thus shortening of the shaft produced by healing of an overriding fracture may be marked at first, but gradually become less and finally disappear as a result of compensatory overgrowth through its epiphyseal lines. This is well illustrated by the observations of David[5] in case of fractures of the shaft of the femur in young children. In a study of seventy-five cases he observed shortening at the end of six to eight weeks, ranging from one-half to two inches in thirty-eight cases. Subsequent study of these cases showed a return to normal length in practically every case in from two to nineteen months depending upon the amount of shortening. An abnormally long bone produced by osteomyelitis in one leg might possibly be expected to set up compensatory overgrowth of the bones of the other leg. Bergmann[6] observed equalization of length years after overgrowth produced by tuberculosis of the knee beginning in early childhood. Compensatory retardation of growth in the normal limb as an equalizing factor

is a possibility but has not been demonstrated. Osborne and Mendel[7] and Winters, Smith, and Mendel[8] have shown that rats have a growth potentiality which may be temporarily slowed down by restriction of certain foods or inorganic salts, but after removal of the restraining influence the loss is quickly made up. However, the skeleton continues to grow during the period of retarded growth and is only slightly smaller than in the controls.

OPERATIVE TREATMENT

In case of disease, tumor, or injury resulting in shortening of bones, the ultimate difference in length of the extremities is often sufficient to result in varying degrees of limp or noticeable deformity. Operative measures designed to equalize the length of limbs have been but little used. They consist of bone lengthening of the shorter limb or bone shortening of the longer limb.

Bone lengthening has been made more practical in recent years by the operation of Leroy Abbott[9, 10]. None of the measures that were previously used gave results that compared favorably with it. While Abbott's operation in the hands of experts has yielded a fairly high percentage of successful results it is a complicated procedure for the average general surgeon and one that should not be lightly attempted by the uninitiated.

Harris[11] has performed lumbar sympathectomy for the purpose of stimulating longitudinal growth in case of shortening of the lower limb due to infantile paralysis. A limb with retarded longitudinal growth during the paralytic stage might undergo compensatory lengthening after increased function from improvement or disappearance of the paralysis. Bisgard[12] performed unilaterial lumbar sympathectomy on young goats and found no difference in length of the posterior extremities at the time of closure of the epiphyseal lines.

Shortening of a bone of the longer limb by resection of a portion of its shaft has been used to a very limited extent in the lower extremity for the correction of slight or moderate limp, but operation has oftenest been performed on adults. Camera[13] has used it twenty-one times in children with good results.

Arrestment of growth at the end of a bone by operative fusion of the epiphysis with the shaft is a procedure, which, if performed at the proper age and location, may serve to so retard growth in the longer extremity as to equalize the length of the two limbs by the time adult life is reached. It may be indicated in the lower extremity for doing away with limp. Excision of an epiphysis or unilateral epiphyseodiaphyseal fusion, with complete arrest of longitudinal growth on one side only, may be indicated in either the forearm or the leg for doing away with curvature or angular deformity, the result of shortening of one of the two bones of the part.

In the following case of dyschondroplasia in a child with shortening and curvature of the left upper and lower extremities, the upper epiphysis of the left radius was excised for correction of deformity of the forearm and the lower epiphysis of the normal right femur was fused with the shaft to arrest longitudinal growth in an attempt at equalization of length of the

FIG. 1

CASE 1. Shortening and chondroma of left femur and fibula; genu valgum of left knee.

lower limbs. Ten years have elapsed since the epiphyseodiaphyseal fusion of the femur and six years since the upper radial epiphysis was excised and full growth of the bones has been attained in the nineteenth year, so that the end results of the operations are known.

CASE 1. Female, present age eighteen years and four months, was first seen at the age of seven years and nine months. The left upper and lower extremities had been shorter than the right since birth. There had been nodules on the bones of the fingers that were slowly increasing in size and there was left genu valgum. There was no history of a similar disturbance in any member of the family. Physical examination at that time revealed a female, fifty-one inches tall, who appeared normal aside from the left upper and lower extremities. The left arm was two inches shorter than the right, the shortening being mainly in the forearm and hand. The radius was slightly curved outward. There were numerous nodules in the course of the finger bones. The left lower extremity measured twenty-four and one-quarter inches from the anterior superior spine to the internal malleolus, while the right measured twenty-seven inches. There was a moderate

left knock-knee. The shortening was mainly in the femur, the left knee being almost two inches higher than the right (Fig. 1). There was slight enlargement of the outwardly curved lower end of the left femur and of the upper end of the left fibula and lower end of the left tibia. Roentgenograms revealed broad streaks of reduced density in the upper end of the left humerus and wing of the left ilium, the upper and lower ends of the shaft of the left femur, the lower end of the left tibia, and the upper end of the left fibula. There were punched-out areas of reduced density in the left finger bones. The left ulna was one and one-half inches shorter than the radius and the shaft of the radius was curved outward (Fig. 2). A diagnosis was made of multiple enchondroma, or Ollier's dyschondroplasia. At the age of eight years and seven months the measurements were as follows: anterior superior spine to internal malleolus,—right, twenty-eight inches, left, twenty-five and one-half inches; top of greater trochanter to lower border of external condyle of femur,—right, fourteen inches, left, twelve inches; tibia,—right, eleven and one-half inches, left, eleven inches. At that time the lower epiphysis of the right femur was fused with the end of the shaft by making incisions mesially and laterally, followed by excision of the cartilagincus disc to a depth of approximately one centimeter along its exposed sides by means of an osteotome and by sliding a bone graft about one by two and one-half centimeters from the lower cortex of the shaft downward into a groove cut into the side of the bony epiphysis so that it bridged the epiphyseal line on either side (Fig. 3). It was estimated that about two inches of longitudinal growth of the femur would be prevented. Subsequent roentgenograms (Fig. 4) showed bony fusion of epiphysis and metaphysis with complete arrestment of longitudinal growth. Figure 5 shows the shortening and deformity that were still present at the age of nine years and eight months. At the age of ten years and four months an osteotomy was performed three inches above the epiphysis of the lower end of the left femur; the hyaline cartilage filling the lateral aspect of the bone was curetted out and the genu valgum corrected. Several of the nodules on the finger bones of the left hand were removed with the curet and found to consist of hyaline cartilage.

FIG. 2

CASE 1. Multiple chondroma of hand, chondroma of lower end of shortened ulna, curvature of radius, and ulnar deviation of hand.

As time went on the disproportion between left radius and ulna increased; the radius became more curved and its head became partly dislocated outward and upward. At the age of twelve years and four months the head (including epiphyseal line) of the left radius was excised with the intention of securing greater equalization of radius

FIG. 3

CASE 1. Right knee, thirty-eight days after operation of epiphyseodiaphyseal fusion of lower end of right femur.

FIG. 4

CASE 1. Forty-three months after epiphyseodiaphyseal fusion of lower end of right femur.

and ulna during the remaining period of growth. Improvement was anticipated more from the excision than from the arrest of growth, since little further increase in length of radius would have resulted at the upper end.

The patient was seen recently, at the age of eighteen and one-third years, or nine and three-quarters years after the arrestment of growth in the lower end of the right femur. The limp in the left leg gradually diminished up to the age of sixteen, since which time it has been slight and has remained stationary. She wears a three-quarters-inch elevation of the left heel which completely does away with it. After excision of the head and neck of the left radius, the curvature of the forearm and angulation of the hand slowly improved. Figure 6 shows the roentgenographic appearance. The patient is five feet, five inches tall. Examination reveals four inches of shortening in the left upper extremity, three of which are in the forearm and hand. The extremity is freely used, but is a trifle weaker than the right. The forearm is slightly curved and the hand slightly smaller than normal. The cartilaginous nodules on the fingers, all of which were excised, except two small ones, have not recurred.

FIG. 5

CASE 1. Shows shortening and genu valgum thirteen months after fusion, age nine years and eight months. Left shoe elevated.

The lower extremities are straight and function normally aside from the slight limp. There is slight enlargement of the left tibia above the ankle, and the foot is one-half of an inch shorter than the right. The left patella is slightly subluxated laterally as a result of the old genu valgum which is now corrected. Measurements from the anterior superior spine to the internal malleolus are as follows: right, eighty-one and one-half centimeters; left, seventy-

nine centimeters. In order to determine more accurately the relative lengths of the bones, a single film teleroentgenogram of the lower extremities was taken with the patient standing at a target distance of nine feet and two inches (Fig. 7). On it the measurements were as follows: right femur, sixteen and one-half inches (41.8 centimeters); left femur, sixteen and one-quarter inches (41 centimeters); right tibia, fifteen inches (38 centimeters), left tibia, fourteen and one-quarter inches (36 centimeters). The roentgenogram shows the lower end of the right femur practically normal in appearance. The upper and lower ends of the left femur, tibia, and fibula show slight expansion and irregular thinning of cortex of ends of the shafts, but shadows of cancellous bone are present, indicating that the cartilaginous areas have been replaced by bone. All epiphyseal lines are closed. Figure 8 shows a roentgenogram of the knees with the legs straight; Figure 9, a photograph at the age of seventeen.

FIG. 6

CASE 1. Condition at age of eighteen years and four months.

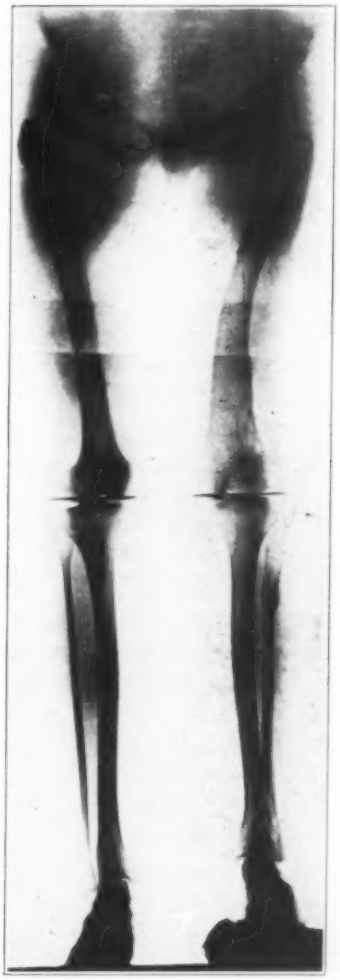

FIG. 7

CASE 1. Teleroentgenogram of lower extremities at age of eighteen and one-third years.

FIG. 8

CASE 1. Knees taken on same film, showing fusion of all epiphyseal lines and healing of chondromata. Left patella subluxated.

The result of the arrestment of longitudinal growth at the lower end of the right femur has been to produce a femur approximately two inches shorter than it would have been and only one-quarter of an inch longer than the diseased left one. This, along with the osteotomy of the left femur, has rescued the patient from a very marked limp and deformity. The slight limp with which she is left, and which will be permanent, is due mainly to the three-fourths inch of shortening in the left tibia and fibula. A better result could have been obtained had the epiphyseodiaphyseal fusion of the lower end of the femur been performed at an earlier date or, preferably, had the same procedure been carried out subsequently on the upper end of the right tibia and fibula at the date—ten to eleven years of age—which would have resulted in one inch of shortening now when longitudinal growth is complete.

FIG. 9

CASE 1. Appearance at age of seventeen.

Because of the success obtained in this case longitudinal growth arrest has been regarded as a justifiable procedure in properly selected cases. Consequently during the past four and one-half years in the University of Chicago Clinics, twenty patients* have been subjected to epiphyseodiaphyseal fusions on the longer side for the purpose of equalizing length of lower limbs, two patients to epiphysectomy, once on the ulna and once on

* Fourteen additional cases operated on at time of proof correction, December 1932.

the fibula, for equalization of length of the two bones in the segment, and one patient to unilateral epiphyseodiaphyseal fusions for the correction of angular deformity at the wrist and ankle due to short ulna and fibula. All except one of the twenty patients with one lower limb shorter than the other have been operated on by Dr. Compere, Dr. Hatcher, or Dr. Keyes during the past nine months. Epiphyseodiaphyseal fusion was obtained in every case, but the time is too short for judging the equalizing influence on length of limbs. The causes of the shortening were: tuberculosis of the hip, eight cases; arrested longitudinal growth from osteomyelitis, two cases; congenital dislocation of the hip, two cases; poliomyelitis, three cases; tuberculosis of the knee, one case; dyschondroplasia, two cases; congenital pseudarthrosis with shortening of tibia, one case; and retarded growth with congenital club-foot, one case. The difference in length of limbs ranged from three and five-tenths to eleven centimeters and the ages from seven to fifteen years. The operation consisted of fusion of the lower epiphysis of the femur in nine cases, and lower epiphysis of femur and upper epiphysis of tibia and fibula in ten cases. The operative technique for fusions about the knee is illustrated by Figure 12.

Incisions six centimeters long are made mesially and laterally exposing the sides of the epiphyseal lines of the femur. A mesial incision exposes the mesial side of the epiphyseal lines of the tibia, and a lateral one the lateral side and also the anterior side of the line of the fibula. A piece of cortex, three centimeters long by one to one and a half centimeters wide, is excised, crossing the cartilaginous line and including about one centimeter of the epiphysis. The sides of the cartilaginous disc anterior and posterior to this are chiseled out to a depth of approximately one centimeter and the transplant reinserted with its ends reversed. In case of the fibula the epiphysis is separated with a chisel, the cartilaginous disc excised, and a metaphyseal graft shifted upward. In some instances the epiphysis of the fibula, including the cartilaginous disc, has been excised.

Case 2. One patient, a boy with dyschondroplasia affecting the ends of both femora and the left tibia, had marked curvature of both lower limbs, moderate shortening of the right limb, and extensive shortening of the left. Four and a half years ago, at the age of nine, he had osteotomy of both femora and the left tibia for correction of deformities and epiphyseodiaphyseal fusion of the lower end of the right femur for equalization of limb length. Two years and seven months ago the difference in length of the limbs still amounted to three and one-half inches and moderate genu valgum right and genu varum left had recurred. Bilateral femoral osteotomy was again performed for correction of the angular deformities and one inch of overriding of fragments was allowed on right femur for the production of shortening. Epiphyseodiaphyseal fusion was performed on the upper ends of the right tibia and fibula. Since then the limbs have remained straight and have gradually approached each other in length until now, at the age of thirteen and one-half years, the left leg is only two inches shorter than the right. Arrest of growth at the lower ends of the right tibia and fibula may become necessary at a later date if equalization does not progress rapidly enough.

In the following case arrest of growth and bone excision were performed for the correction of deformity at the wrist.

FIG. 10

CASE 2. Shortening of radius and obliquity of its lower epiphysis at age of twelve, resulting from fusion of epiphysis and shaft anteriorly at age of four.

CASE 3. Epiphyseal excision was practised in the case of a girl who had marked shortening of the radius with extreme prominence of the lower end of the ulna and radial angulation of the hand. This was the result of injury to the anterior portion of the epiphyseal line from excision of a cartilaginous exostosis of the lower end of the shaft of the radius at the age of four. A bony bridge formed anteriorly, but longitudinal growth continued posteriorly. Figure 10 shows the anterior angulation of the lower radial epiphysis and the backward and downward projection of the ulna beyond the wrist joint at the age of twelve. Osteotomy of the radius was then performed and the angulation of the lower fragment was corrected. At the age of thirteen the lower epiphysis, including the cartilaginous disc, was excised, thereby shortening the ulna and preventing further longitudinal growth. At the age of sixteen (Fig. 11) the ulna extends but slightly beyond the line of the wrist joint and the deformity is considerably improved. Practically the maximum improvement has been reached since very little future growth will take place from the upper end of the radius.

In the following case unilateral arrest of growth was practised for correction of angulation at the wrist and ankles.

CASE 4. A boy, aged twelve years, had multiple cartilaginous exostoses with shortening of both ulnae and both fibulae. On the right side the ulna was one and three-quarters inches shorter than the radius, as a result of which there was curvature of the radial shaft and ulnar inclination of the lower radial epiphysis and wrist. The shortening in the fibula had resulted in outward displacement of the astragalus on either side beneath the external malleolus and external obliquity of the lower tibial epiphysis, more marked on the left side. At the age of twelve epiphyseodiaphyseal fusion was carried out on the lateral side of the lower end of the radius. This resulted in arrested longitudinal growth of the radius laterally, but it continued on the ulnar side and one month ago, or two years and two months later, the epiphyseal line had lost its obliquity, thereby lessening

FIG. 11

CASE 2. Condition at age of sixteen, three years following excision of lower epiphysis of ulna and four years after osteotomy and correction of obliquity of radial epiphysis.

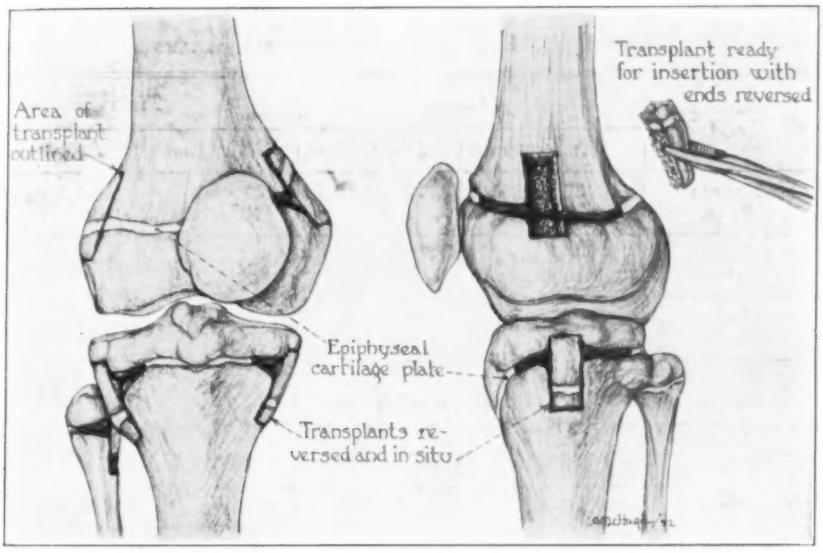
Area of transplant outlined
Transplant ready for insertion with ends reversed
Epiphyseal cartilage plate
Transplants reversed and in situ

FIG. 12

Sketch of technique of epiphyseodiaphyseal fusion. Transplants reversed and cartilage chiseled out.

considerably the ulnar angulation of the hand. The ulnar longitudinal growth had been but slight. At that age unilateral epiphyseodiaphyseal fusion was carried out on the mesial side of the lower end of either tibia in the hope that subsequent downward growth of the lateral portion of the tibia and of the fibula will correct the eversion of the ankles by the time adult life is reached.

DISCUSSION

When equalization of length of limbs is attempted by epiphyseodiaphyseal fusion the greatest care should be exercised in the choice of time, and location and number of epiphyses to be fused. In some instances the lower epiphysis of the femur should be fused, in others the upper epiphyses of tibia and fibula, while in still others both the lower femoral and the upper tibial and fibular epiphyses should be fused, either at the same time or at different times according to the amount of shortening to be accomplished.

Measurements should be made of body length, length of limbs, and total, and diaphyseal lengths of the bones to be compared. These are made in the usual way, but length of the long bones and of their diaphyses are best made from teleroentgenograms of the entire lower extremities. Table I gives the measurements of normal femora and tibiae in six individuals during the growing period from teleroentgenograms taken at a target distance of nine feet, two inches (280 centimeters) which are sufficiently near the actual lengths to be used for comparison. Table II gives measurements for different ages obtained by Toldt[15] from skeletons.

The differences in lengths of the homologous limbs, bones, and diaphyses are thus obtained.

TABLE I

LENGTHS MEASURED FROM TELEROENTGENOGRAMS

Sex and Age	*Femur*		*Tibia*	
	Entire bone	*Diaphysis*	*Entire bone*	*Diaphysis*
Female 8 yrs.	37 cm. 14½ in.	33 cm. 13 in.	31 cm. 12⅛ in.	28.3 cm. 11⅛ in.
Male 12 yrs.	40 cm. 16 in.	36.8 cm. 14¼ in.	31.7 cm. 12½ in.	29 cm. 11⅜ in.
Female 13 yrs.	42.8 cm. 16⅞ in.	39.5 cm. 14⅜ in.	36.5 cm. 14⅜ in.	33½ cm. 13¼ in.
Female 13 yrs.	44.5 cm. 17½ in.	39.7 cm. 15⅝ in.	35.5 cm. 13⅞ in.	32.6 cm. 12⅞ in.
Male 14 yrs.	44.5 cm. 17½ in.	39.6 cm. 15⅝ in.	35 cm. 13¼ in.	32.4 cm. 12¾ in.
Male 16 yrs.	48 cm. 19⅛ in.	43.2 cm. 17 in.	39 cm. 15½ in.	36.5 cm. 14⅜ in.

The next problem is to try to estimate the amount of longitudinal growth that will henceforth take place in the respective limbs, bones, and diaphyses and also the amount from either end of each diaphysis concerned. From these data the inequality in length of limbs that will obtain in adult life may be estimated. There may be a good deal of inaccuracy in such estimations because of a number of factors. As previously stated, the rate of growth in the shortened limb may vary according to whether or not the cause of the shortening remains active. The same is true for a limb lengthened as a result of disease such as osteomyelitis. Allowance should be made for this fact in making estimations. Another factor is that the amount of longitudinal growth which takes place from each end of the diaphysis of the various extremity bones has not yet been determined with great accuracy. Different methods have been employed. Stephen Hales [16] in 1747 pierced two holes in the cortex of the tibia of a growing chicken and two months later found the distance between them to be the same, but the bone had increased in length one inch, most of which had occurred at the upper end. Thus he demonstrated the absence of interstitial growth in the shaft and the presence of unequal longitudinal growth at the ends of the shaft.

Similar and somewhat more accurate observations were made by Duhamel who implanted silver stylets and by John Hunter who implanted shot in the shafts. It had long been known that the epiphysis fuses with the shaft earlier at one end than at the other and the view prevailed that because of this there is more increase in length from the end at which fusion occurs last.

Broca in 1852 observed that the cartilage disc between bony epiphysis and diaphysis is thicker at one end than at the other, that the canal

for the nutrient artery is farther away from the thicker cartilage disc and becomes proportionately more so with increasing age. From this he deducted that there is more longitudinal growth at the end of the shaft with the thicker cartilage disc.

Humphrey [18] in 1861 reported experiments in which he fed madder to hogs and noted greater longitudinal growth from one end than from the other after the madder was stopped. He also noted that the nutrient canal slopes away from the end of the bone at which the epiphysis closes last and that there is more rapid and prolonged growth at this end.

Ollier [17] implanted shot in the middle of the shaft of bones of young rabbits and determined the amounts of growth from the two ends after varying intervals. He found for the fore limb the least growth from the end nearest the elbow and for the hind limb the most growth from the end at the knee. He reported one-fifth of the longitudinal growth of the arm and forearm bones from the ends at the elbow and almost two-thirds of that of the thigh and leg bones from the ends at the knee which for the forearm and leg bones is very inaccurate. Ollier also observed clinically that resection of the knee early in life, as for tuberculosis in which the epiphyses were removed, resulted in marked limb shortening, whereas similar resection of the elbow resulted in little shortening.

Perhaps the most accurate method reported for estimating the amount of longitudinal growth that takes place at the ends of the various bones is that employed by Digby. He prolonged the axis of the nutrient foramen to the center of the medullary canal of the shaft and reckoned that as the point of primary ossification. The distance from this point to each end of the shaft represents the amount of diaphyseal growth from that end. The results in one adult skeleton were as follows:

TABLE II

TOLDT'S TABLE OF TOTAL AND DIAPHYSEAL LENGTHS OF FEMUR AND TIBIA

Sex and Age	*Femur*		*Tibia*	
	Entire bone	*Diaphysis*	*Entire bone*	*Diaphysis*
Female 4 yrs.	21.3 cm.	18.2 cm.	17.8 cm.	15.3 cm.
Male 6½ yrs.	25.6	22.2	20.3	17.6
Male 12 yrs.	38.3	34.5	30.8	28
Male 15 yrs.	42.2	38.3	35.3	32.1
Male adult—average of 9	46.7		37.4	
Female adult	41.1		33.5	

Femur—upper end, 5 inches; lower end, 11 inches.
Tibia—upper end, 7½ inches; lower end, 5 inches.
Fibula—upper end, 7½ inches; lower end, 5 inches.
Humerus—upper end, 9½ inches; lower end, 2½ inches.
Radius—upper end, 2 inches; lower end, 6 inches.
Ulna—upper end, 1¾ inches; lower end, 5⅝ inches.

No similar measurements have been reported for growing skeletons.

I measured in this way the diaphyses of humerus, femur, and tibia of a sixteen-year-old male skeleton with the following results:

Left humerus—upper end, 21.8 centimeters; lower end, 7 centimeters.
Left femur—upper end, 13 centimeters; lower end, 28½ centimeters.
Left tibia—upper end, 19.5 centimeters; lower end, 15.8 centimeters.

These measurements correspond well with those of Digby.

Stevenson [14] gives the dates of fusion of the epiphyses with the shaft of the various bones as follows: humerus—upper end, twenty years, lower end, fifteen years; radius—upper end, eighteen years, lower end, nineteen years; ulna—upper end, seventeen years, lower end, nineteen years; femur—upper end, eighteen years, lower end, nineteen years; tibia—upper end, seventeen years to nineteen years, lower end, eighteen to nineteen years; fibula—upper end, seventeen to nineteen years, lower end, eighteen to nineteen years.

Roentgenographic studies of the diaphyses of bones that contain transverse striations as a result of interference with growth during illness, as scarlet fever, or as a result of phosphorus administration [19], demonstrate well the difference in the rate and amount of growth at the two ends of the various bones, but no accurate measurements have been made in this way. They show growth rates somewhat similar to those of Digby's.

Payton [21] has recently studied the growth in length of bones of the madder-fed pig. He found that the rate of growth diminishes with age, the diminution being more rapid at the end of lesser increment and earliest cessation. The quantitative ratios of growth from the two ends were different from those calculated for man by the method of Digby [20].

From the evidence at hand, it appears to be not entirely safe to draw conclusions as to the rates of growth at the two ends of a bone in man from those calculated for experimental animals.

More accurate studies of the total length of the growing shafts should be made for children of different ages by means of teleroentgenograms *, and attempts should be made to determine the percentages of growth at the two ends by roentgenographic studies of patients with transverse striations in the metaphyses, such as result from scarlet fever.

In considering the indication for shortening in the lower limb, it is important to remember that the patient is more concerned about deformity than about height, and that one does not care greatly whether one is five feet, eight inches, or five feet, eleven inches tall, as long as there is no limp.

* Since this was written, measurements have been made by Dr. Paul C. Hodges of our x-ray department by the stereotriangulation method. Working at a target distance of sixty inches with a tube shift of five inches and using eight by thirty-six inch films, the results have been very accurate.

CONCLUSIONS

1. Selected cases of inequality of length of limbs during the growing period may be treated by epiphyseodiaphyseal fusion, arresting growth in the longer limb, and thereby approximating or equalizing limb lengths at the end of the growth period.

2. Angular deformities of the wrist or ankle, the result of disproportion in length of the two bones of the forearm or leg, may be improved by either unilateral or complete arrest of growth in the longer bone at the appropriate age.

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EARLY TREATMENT OF CONGENITAL DISLOCATION OF THE HIP * †

BY PROF. VITTORIO PUTTI, BOLOGNA, ITALY

I wish first of all to apologize to my colleagues of the British Orthopaedic Association because, after having been so highly honored as to be invited to this Congress, I have again chosen as my subject the same that I dealt with here on the occasion of the Joint Meeting of the American and British Orthopaedic Associations.

My reasons for this choice are primarily two:

1. Because I consider that the treatment of congenital dislocation of the hip is still a matter not merely of fundamental importance to orthopaedic surgeons, but also one on which the last word has not yet been spoken, and which, therefore, it is opportune to discuss afresh.

2. Because I considered it my duty to report to my colleagues of the British Orthopaedic Association the results which I have obtained up to date with the abduction method, since in 1929 I could only refer to a very limited number of cases.

I have already said that the treatment of congenital dislocation of the hip is still a subject open for discussion, and I sincerely believe that it should be discussed. More than forty years after the discovery of the method which its originator, Agostino Paci, called the rational and radical one, we cannot say that we have arrived at unanimity as to the methods to be adopted, nor in the estimation of results.

Thus, among English-speaking surgeons there are not a few who even now uphold the advisability of resorting much more often to reduction by open operation; while on the Continent of Europe the conviction is prevalent that closed reduction should be given the preference. Even more diverse are the opinions as to postoperative treatment. As to results, it is not to be disputed that not until the present time have we been in a position to give a balanced judgment on the actual value of the treatment. Indeed, not less than thirty years of experience were necessary to determine how a reduced joint would behave in advancing age,—in other words, what fate awaits it in the inevitable course of aging of the individual. And for those who can interpret it, for those who can command vast statistics, for those who are analyzing a well organized, well recorded material, this experience is highly instructive.

The German orthopaedic surgeons presented their experience at the Congress of Munich in 1929. Their analysis of results obtained in about thirty years on about 1500 cases, seen after a minimum period of three years from reduction, has led to rather comforting conclusions,—perfect and permanent results in nearly half the cases reexamined.

* Read at the meeting of the British Orthopaedic Association, London, July 27, 1932.
† Translated by Dr. Maud F. Forrester-Brown.

I cannot foretell what conclusions the Italian orthopaedic surgeons will bring before the Congress which is to be held in Bologna next October; but, judging by the statistics of the Istituto Rizzoli alone, based on 3216 cases, of which about 600 were reexamined at a minimum period of five years after treatment, I think that the percentages will not be very different from those presented by the German surgeons.

This means that, contrary to what was assumed from the examination of cases recently treated, there is still a high percentage of dislocations in which the results of treatment are not completely satisfactory, or not satisfactory at all.

Many conclusions may be drawn from a study of the results of cases examined at periods of from five to thirty years later, but I shall limit myself to pointing out the principal ones:

1. It is a complete delusion that one can have a result permanently satisfactory in function in a hip incompletely reduced. This delusion has led to a too optimistic view of the results. Clinical and roentgenological observations of cases examined from five to thirty years after the end of treatment demonstrate irrefutably that every subluxated, or transposed hip, every hip in which one has not obtained from the first, or not preserved, normal anatomical relationship between the femoral epiphysis and the acetabulum, every such hip is inevitably destined to become the subject of that precocious articular senility, which is usually diagnosed as osteo-arthritis, or arthritis deformans. In other words, *no complete and permanent restoration of function occurs apart from perfect anatomical reduction.*

On the contrary, one cannot say that perfect anatomical reduction is synonymous with perfect function, because even the hip perfectly reduced may be subjected to reactive processes, which may compromise its function.

2. The primary causes of imperfect reduction or instability are anatomical in nature and are sufficiently well known to make it unnecessary for them to be dwelt upon. I consider that, rather than the bony abnormalities, it is those of the capsule and ligaments which are important. This conviction I acquired through the study of ten dissections of dislocations, the details of which I am about to publish.

3. The most uncertain element, on which the success of treatment depends, is the reactive processes to which the joint components are exposed, due either to the traumatism of the reduction or to prolonged immobilization. A very important factor in determining this reactive process is the constitutional one,—that is, the tendency of the individual to resent such mechanical stimuli as the joint encounters during reduction. The manifestations of joint reaction fall into two primary groups,—generalized osteo-arthritis, involving all the parts of the joint, and osteochondritis, which affects chiefly the femoral epiphysis.

4. The age of the patient is the most important factor in the result. This conclusion, on which we insisted in presenting our statistics to the Congress of Florence in 1913, is fully confirmed by an analysis of the cases

operated on in the last twenty years, even when one excludes those treated under the thirteenth month, of which I shall speak shortly.

It is well known how the structure of every joint, as well as its function, is completely dominated by the age of the individual. This axiom applies to the joint congenitally dislocated, but acquires special importance when it is considered in relation to the effects of the manoeuvers, which must be carried out in order to restore the joint to normal.

Statistics demonstrate irrefutably the effect of the age, at which treatment is started, on the results. Since we placed the maximum age for single dislocations at seven years, and for bilateral ones at four years, the percentage of successes has increased notably. But one is still too often induced to operate after these ages, and this mistake results in a lowering of the total percentage of successes.

I have referred to the age limits which up to now we consider the maximum. What is the minimum? If we consider the statistics of recent years in which the majority of patients have been operated on in what is generally considered the most favorable age,—that is, from the second to the third year—we see that the percentage of successes is undoubtedly improved; but it is still far below a satisfactory figure.

The causes of failure, apart from errors of technique, are, even at this age, the same that I have already indicated,—anatomical obstacles to primary, perfect reduction, resulting in appositions, transpositions, redislocations; and arthritic reactions, which cause contractures, stiffness, pain, and ankylosis. In other words, even in what is generally considered the ideal age for treatment, one encounters, though in lesser measure, the troubles which are so frequent in later life. Therefore one must reduce the age limit, *indeed abolish it completely*, and fully accept that principle, which all orthopaedic surgeons follow in the treatment of all congenital deformities, and which one sees no reason to repudiate in that of congenital dislocation of the hip,—that is, *to begin treatment the very moment the deformity is observed*, even if that be on *the day of birth*.

I explained in various publications and also to the Meeting in London in 1929 what the symptoms are which indicate a dislocation in the early days of life, so that it seems superfluous to repeat them. Increased experience has taught me to attach even more importance to the roentgenogram, and for that reason I gladly take the opportunity to insist again on a suggestion that I made long ago,—the necessity of submitting every new-born child to a routine x-ray examination of the hips. This suggestion appeared to some absurd, to others impracticable, and to still others not free from danger.

It can only appear absurd to those who do not consider the seriousness of a dislocation in regard to both individual and social life. That it is impossible to carry out will not seem likely, if we remember the widespread facilities for roentgenography already available and their certain increase in the future. As to the risks of exposing a new-born child to the action of x-rays, I do not think it exists, in view of the extreme rapidity of exposure made possible by modern apparatus.

TABLE I

CASES OF CONGENITAL DISLOCATION TREATED BY ABDUCTION METHOD

Year	*Number*
1921–22	1
1923	1
1924	1
1925	1
1926	2
1927	6
1928	11
1929	28
1930	33
1931	35
Total	119

As shown in Table I the total number of cases is 119. It is not without interest to note the steady increase in the number of cases treated from 1922 to 1931. This progressive and suggestive increase is not accidental, but the result of increased experience in the recognition of dislocations, thanks chiefly to the greater use of roentgenological examinations and to the propaganda on a large scale among University students, practitioners, and more particularly among obstetricians, pediatricians, and mid-wives.

At first I hesitated to admit the existence of a state of *predislocation*, except when the clinical signs and x-ray findings agreed in making the diagnosis certain. Experience in a few cases, in which I have seen transformed, under my very eyes, a state of predislocation, evidenced merely by an increased tilting of the roof of the acetabulum and few clinical signs, into a complete dislocation, such an experience has taught me to rely completely on the roentgenological findings, which I now consider sufficient to prove a state of predislocation, even in the absence of any clinical signs whatever.

That propaganda designed to spread the knowledge of the existence of this condition of predislocation has borne good fruit is proved by various evidences. Indeed, not a small percentage of the patients treated by the abduction method were sent to us by pupils and colleagues.

The second table seems to us of some importance as it shows that, in a comparison between predislocations and frank dislocations, the percentages of the sexes and sites of dislocation do not differ much; wherefore, one may draw the conclusion that a predislocation is really a potential dislocation.

As to the age at which treatment was started,—the youngest case of predislocation was a baby thirty-four days old, and the oldest sixteen months. The average age (nineteen cases) was four months. Only four babies were more than one year old. The shortest term of treatment was four months, the longest twenty months. In the majority (sixty-three cases) the duration was seven to nine months.

As regards the technique of the abduction method, I have nothing new to add to what I already explained in my writings and at the London

Meeting in 1929. I found it best to modify the abduction apparatus by making the two hips independent of one another, so that one could at will graduate the degree of abduction in each limb separately.

RESULTS

Out of the 119 cases I obtained complete cure in 113, that is in ninety-four and nine-tenths per cent. If from the six unsuccessful cases we exclude one, in which failure was due to the mother's neglect to carry out our directions, the percentage is increased to ninety-five and seven-tenths. Of the remaining five cases, all bilateral, in two, failure of the abduction treatment was on one side only. The unreduced hip was later reduced by the manipulative method. That leaves only two cases in which the method failed completely. These were two infants, aged three and five months respectively, who, in addition to double congenital dislocation of the hips, had club feet, and rigidity of the knees and elbows. In these two cases, manipulation also was quite unsuccessful.

Although the statistics which I have presented are not yet numerous enough to allow of a final decision as to the value of the method, yet I think that for the moment it justifies the following conclusion:

A method, which avoids all operative trauma, which dispenses with all anaesthesia, which is incomparably less risky and less complicated than that in common use, *such a method, in cases of congenital dislocation under twelve months of age, gives a high percentage of results anatomically and functionally perfect.*

Before concluding, I wish to consider the two fundamental criticisms, which have been made against the abduction method.

TABLE II

CONGENITAL DISLOCATION OF THE HIP

GENERAL STATISTICS OF CASES TREATED AT THE ISTITUTO RIZZOLI FROM 1899 UP TO 1931

3216 CASES

Females	2725	(84.7 per cent.)	Males	491	(15.2 per cent.)
Bilateral	1476	(43.8 per cent.)	Unilateral	1740	(54.1 per cent.)
Right side	1081	(33.6 per cent.)	Left side	659	(20.4 per cent.)

CASES TREATED WITH THE ABDUCTION METHOD

119 CASES

Females	84	(70.5 per cent.)	Males	35	(29.4 per cent.)
Bilateral	52	(43.6 per cent.)	Unilateral	67	(56.3 per cent.)
Right side	50	(42.0 per cent.)	Left side	17	(14.2 per cent.)

It has been said that the practical value of this method can only be relative, since the dislocations are usually brought under the observation of the orthopaedic surgeon too late for such a method to be applied.

It seems to me that such an objection can only have weight with those who despair of the future of our speciality; I cannot believe that it can enter the mind of any modern orthopaedic surgeon. If heretofore we have not

troubled to recognize dislocations very early, or, in other words, to seek out predislocations, because we thought it unnecessary to begin treatment before the age of one year, now that it has been demonstrated that the results obtained by intervention below this age limit are incomparably better than those obtained after it, it is the duty of every orthopaedic surgeon to popularize this principle, and to spread among medical classes the knowledge of the chief signs of an early dislocation, and to insist on the routine x-ray examination of all new-born infants.

What today may seem the exceptional method, in the future will in all probability become the method of choice, and the orthopaedic surgeon will thus have taken a great step forward in the treatment of congenital dislocation.

Now let us pass to the second criticism. It is known that congenital dislocation can undergo spontaneous reduction. The figures proving this are not numerous,—forty-five cases according to Marconi's recent work; but the fact is indisputable.

Bearing this in mind, it has been said that it is highly probable that some of those cases, which I have designated predislocations, would have undergone spontaneous cure,—that is without the abduction treatment.

Although there is no lack of arguments to demonstrate the essential inconsistency of this criticism, I prefer to accept it as it is. But I cannot ignore the following considerations: Granting that some predislocations might reduce themselves spontaneously, who today, face to face with a clearly demonstrated case of predislocation, would feel himself justified in omitting the application of a harmless therapeutic measure, which is simple and inexpensive, and is calculated not merely to prevent and cure a dislocation under the most favorable conditions, but to avoid the two possibilities, which face every individual whose hips are not anatomically perfect? These two possibilities are:

1. The arthritic reaction, which may develop in the course of treatment, a reaction which we cannot prevent, because it is in great part dependent on obscure factors of constitutional nature, and which can only be avoided by very early treatment.

2. Subluxation, which is almost always overlooked and often neglected, until it becomes obvious at an age when no radical cure is available and it becomes the cause of the syndrome of arthritis deformans, which is only slightly amenable to therapeutic measures. Calot estimates subluxations as ten times more common than dislocations. From the statistics of the Istituto Rizzoli we conclude that forty per cent. of cases of arthritis deformans in the adult are based on congenital subluxations.

If, in view of these two possibilities, we have needlessly submitted a case of predislocation to a gentle and harmless form of treatment, when it might have been lucky enough to reduce itself spontaneously, this is not in itself a ground for discrediting a method, in which, according to our views, lies the *only secret which can improve the results of the treatment of congenital dislocation of the hip.*

OPERATIVE FIXATION OF TUBERCULOUS HIPS IN CHILDREN *

End-Result Study of Thirty-Three Patients from the Orthopaedic Department of the Childrens' Hospital

BY JOHN C. WILSON, M.D., LOS ANGELES, CALIFORNIA

A review of the recent writings on the treatment of tuberculosis of the hip joint indicates that the trend is toward surgical fusion. It is generally agreed that a healed tuberculous joint will not permit a useful range of motion. Bony ankylosis of the affected joint is the ultimate objective with any form of treatment.

British surgeons have been strong advocates of conservative measures but Girdlestone in the Jones Birthday Volume states that fusion is always indicated in adults. Eighteen months of conservative treatment is recommended for children. A fusion is done if this does not give a free and painless range of motion. Mercer writes that conservative treatment is discouraging and recommends the Hibbs operation when destruction is extensive. Wade is not satisfied with conservative treatment but questions the advisability of fusion operations in children. Measures to ankylose the joints by surgical aid are advised for adults. Glissan states that ankylosis is the only cure, but does not consider operative methods to produce it. Bristow recommends operative treatment in certain cases irrespective of age. Hibbs's method is preferred.

Some of our more conservative American authors are advocating operative treatment to obtain ankylosis in adults. Henderson advises conservative treatment in children and operative measures in adults to obtain ankylosis. He does not suggest any particular type of operation.

While intra-articular operations are rather universally condemned, Key thinks that they are justifiable when coupled with a packing in of osteoperiosteal grafts between the ilium and neck of the femur. This treatment is recommended only for individuals over ten years of age. Farrell reports ten cases of intra-articular fusion by denuding the cartilage from the head of the femur and acetabulum with eighty to ninety per cent. of failures. He also states that an operation to be of any practical value must be applicable to children.

The idea of producing a bony ankylosis of the hip joint by an extra-articular procedure is not new. Albee in 1919 described a fusion of the hip by using tibial grafts as struts between the crest of the ilium and great trochanter. Kappis, in 1920, bridged from the crest of the ilium to the trochanter with an osteoperiosteal graft from the tibia. He reported a series of twenty cases in 1924, some of which were unsuccessful. Baron

* Presented at the Annual Meeting of the American Orthopaedic Association, Toronto June 16, 1932.

reported a plastic fusion operation in 1921. Flaps from the ilium and trochanter were overlapped and secured by an osteoperiosteal graft from the tibia. Haas in 1922 reported three cases in which fusion was obtained by implanting the great trochanter into the ilium without opening the joint capsule.

The Hibbs operation published in 1926 has become most popular, stimulating a wide-spread interest in the joint tuberculosis problem. Hibbs's operation is in principle a bone graft swung from the femoral trochanter to the ilium without complete interruption of the blood supply. Schumm in 1929 described an operation in which the graft, used to bridge the gap between the trochanter and ilium, is taken from the upper third of the femur. Ghormley in 1931 described an ingenious operation to produce ankylosis of the hip joint. A section of iliac crest is inserted into a slot carefully prepared in the trochanter and ilium, acting as a key. Abbott and Fisher call attention to the fact that extensive destruction of the head of the femur and acetabulum allow close approximation of the great trochanter and ilium. Such cases lend themselves to direct fusion between the ilium and trochanter after denudation of contacting bony surfaces and wide abduction. Osteotomy is done later and the callus is bent sufficiently to allow correction of the abduction deformity.

In 1927 the first iliofemoroplasty or pedicle-flap operation was described by the author. Stress was laid upon the fact that this was not a bone-grafting operation because the distal end of the flap retains its continuity. A part of the blood supply at least is undisturbed. While the operation has been described as extra-articular, this is not true in every detail. The joint capsule is opened to expose the neck of the femur but the joint surfaces are not invaded.

No large series giving end results of operations to ankylose tuberculous hips in children has been reported up to the present time. Albee reported thirty-one cases with very satisfactory clinical and functional results in all instances. This series includes one child aged three and one-half years, two aged four years, one aged eleven years, and one child age not stated. Out of these five cases, two are reported as having good results and two excellent.

Hibbs in 1926 gave a preliminary report of twenty cases, drawing no conclusions as to value of the operation. He observed that fusion first occurred between the trochanter, graft, and ilium, to be followed by consolidation in the area of disease. Solid ankylosis as demonstrated by clinical and x-ray examination was found in eighty to ninety per cent. of the cases. An operative mortality of five per cent. was reported. Thirty per cent. of the surgical wounds drained.

Kidner reported, in 1928, sixteen cases between four and fourteen years of age with firm bony union in eleven. The Hibbs operation was done. Four were cured, two were still under treatment, and one died from meningitis. He thinks twenty to forty degrees of flexion of the hip with a neutral position relative to abduction and adduction is the most

TABLE I

	Sex	Duration of Symptoms	Previous Operations	Age at Iliofemoroplasty	Sinus	Tissue	Subsequent Operations	Ab
Case 1	F	3 years 6 months	0	7 years	0	0	0	
Case 2	F	5 years	0	8 years 6 months	+	+	0	+
Case 3	M	2 years 3 months	0	10 years	0	0	0	0
Case 4	F	4 years	1st. Drainage abscess 2nd. Arthrodesis by fibular transplant	9 years 6 months	0	0	0	0
Case 5	M	7 years	0	10 years	0	+	0	+
Case 6	M	6 months	0	4 years	0	0	0	0
Case 7	F	4 years	0	9 years 6 months	0	0	0	0
Case 8	M	1 year	0	7 years	0	+	0	+
Case 9	F	Unknown	Intra-articular arthrodesis	6 years	0	0	0	0
Case 10	F	2 years	0	4 years 6 months	0	+	0	0
Case 11	M	1 year 8 months	0	10 years	0	+	0	+
Case 12	F	1 year	0	9 years	0	0	Aspiration of abscess over trochanter, 1 year 8 months after 1st operation. No drainage subsequently. Subtrochanteric osteotomy 4 years 8 months after iliofemoroplasty	+
Case 13	M	6 months	0	4 years 6 months	0	+	0	
Case 14	M	Unknown	1st. Fibular graft. 2nd. Reinsertion of fibular transplant	8 years	+	0	0	+
Case 15	F	5 months	0	8 years	0	+	New iliac flap 7 months after 1st operation	0
Case 16	F	2 years 6 months	Aspiration of abscess	7 years	+	+	0	+

TABLE I—*Continued*

...IONS	ABSC...		DRAINAGE	PERIOD OF IMMOBILIZATION AFTER OPERATION	CLINICAL FUSION	X-RAY FUSION	POSITION-SHORTENING	NUTRITION	TIME SINCE FUSION
0	+	Case 1	0	Undetermined	+	+	Flexion 20°—Abduction 15° Rotation neutral Shortening 2 cm.	Good	7 years
+	+	Case 2	6 months post-operative	6 months	+	+	Flexion 20°—Abduction 10° Ext. rotation neutral Shortening 1 cm.	Excellent	6 years 3 months
0	+	Case 3	0	9 months	+	+	Flexion 50°—Abduction 10° Rotation neutral Shortening 2 cm.	Excellent	6 years
0	+	Case 4	0	Undetermined	+	+	Flexion 20°—Adduction 10° Rotation neutral Shortening 2 cm.	Excellent	6 years
+	+	Case 5	8 months post-operative	9 months	+	+	Flexion 15°—Abduction 10° Ext. rotation 15° No shortening	Good	5 years 5 months
0	+	Case 6	0	6 months	+	+	Flexion 40°—Abduction 10° Ext. rotation 30° Shortening 4 cm.	Excellent	5 years 4 months
0	+	Case 7	0	10 months	+	+	Flexion 15°—Abduction 15° Rotation 10° Shortening 1 cm.	Excellent	5 years 4 months
+	+	Case 8	6 months post-operative	9 months	+	+	Unknown	Unknown	5 years 3 months
0	+	Case 9	5 years 3 months after operation. Draining slightly at present. Hip solid	6 months	+	+	Flexion 20°—Adduction 10° Rotation neutral Shortening 10 cm.	Excellent	5 years 3 months
0	+	Case 10	1 year 8 months	2 years	+	+	Flexion 35°—Abduction 15° Ext. rotation 10° No shortening	Excellent	5 years 2 months
+	+	Case 11	6 months	1 year	+	+	Flexion 50°—Abduction 15° Ext. rotation neutral Shortening 4 cm.	Excellent	5 years
+	+	Case 12	0	8 months	+	+	Flexion 10°—Abduction 5° Rotation neutral Shortening 1 cm.	Excellent	5 years
	+	Case 13	1 year 8 months	1 year 8 months	+	+	Flexion 15°—Abduction 10° Rotation neutral Shortening 1 cm.	Good	4 years 8 months
+	+	Case 14	3 months	5 months	+	+	Flexion 20°—Abduction 10° Rotation neutral Shortening 2 cm.	Excellent	4 years 6 months
0	+	Case 15	6 months following 2nd operation	6 months after 2nd operation	+	+	Flexion 15°—Abduction 10° Rotation neutral Shortening 1 cm. after osteotomy	Good	4 years
+	+	Case 16	1 year postoperative	1 year	Failure	Flap absorbed. Extensive acetabular destruction 1 year after operation	Not fused	Fair	3 years 11 months

TABLE I

	Sex	Duration of Symptoms	Previous Operations	Age at Iliofemoroplasty	Sinus	Tissue	Subsequent Operations	Abscess
Case 1	F	3 years 6 months	0	7 years	0	0	0	0
Case 2	F	5 years	0	8 years 6 months	+	+	0	+
Case 3	M	2 years 3 months	0	10 years	0	0	0	0
Case 4	F	4 years	1st. Drainage abscess 2nd. Arthrodesis by fibular transplant	9 years 6 months	0	0	0	0
Case 5	M	7 years	0	10 years	0	+	0	+
Case 6	M	6 months	0	4 years	0	0	0	0
Case 7	F	4 years	0	9 years 6 months	0	0	0	0
Case 8	M	1 year	0	7 years	0	+	0	+
Case 9	F	Unknown	Intra-articular arthrodesis	6 years	0	0	0	0
Case 10	F	2 years	0	4 years 6 months	0	+	0	0
Case 11	M	1 year 8 months	0	10 years	0	+	0	+
Case 12	F	1 year	0	9 years	0	0	Aspiration of abscess over trochanter, 1 year 8 months after 1st operation. No drainage subsequently. Subtrochanteric osteotomy 4 years 8 months after iliofemoroplasty	+
Case 13	M	6 months	0	4 years 6 months	0	+	0	
Case 14	M	Unknown	1st. Fibular graft. 2nd. Reinsertion of fibular transplant	8 years	+	0	0	+
Case 15	F	5 months	0	8 years	0	+	New iliac flap 7 months after 1st operation	0
Case 16	F	2 years 6 months	Aspiration of abscess	7 years	+	+	0	+

TABLE I—*Continued*

Abscess		Drainage	Period of Immobilization After Operation	Clinical Fusion	X-Ray Fusion	Position-Shortening	Nutrition	Time Since Fusion
0	Case 1	0	Undetermined	+	+	Flexion 20°—Abduction 15° Rotation neutral Shortening 2 cm.	Good	7 years
+	Case 2	6 months post-operative	6 months	+	+	Flexion 20°—Abduction 10° Ext. rotation neutral Shortening 1 cm.	Excellent	6 years 3 months
0	Case 3	0	9 months	+	+	Flexion 50°—Abduction 10° Rotation neutral Shortening 2 cm.	Excellent	6 years
0	Case 4	0	Undetermined	+	+	Flexion 20°—Adduction 10° Rotation neutral Shortening 2 cm.	Excellent	6 years
+	Case 5	8 months post-operative	9 months	+	+	Flexion 15°—Abduction 10° Ext. rotation 15° No shortening	Good	5 years 5 months
0	Case 6	0	6 months	+	+	Flexion 40°—Abduction 10° Ext. rotation 30° Shortening 4 cm.	Excellent	5 years 4 months
0	Case 7	0	10 months	+	+	Flexion 15°—Abduction 15° Rotation 10° Shortening 1 cm.	Excellent	5 years 4 months
+	Case 8	6 months post-operative	9 months	+	+	Unknown	Unknown	5 years 3 months
	Case 9	5 years 3 months after operation. Draining slightly at present. Hip solid	6 months	+	+	Flexion 20°—Adduction 10° Rotation neutral Shortening 10 cm.	Excellent	5 years 3 months
	Case 10	1 year 8 months	2 years	+	+	Flexion 35°—Abduction 15° Ext. rotation 10° No shortening	Excellent	5 years 2 months
	Case 11	6 months	1 year	+	+	Flexion 50°—Abduction 15° Ext. rotation neutral Shortening 4 cm.	Excellent	5 years
	Case 12	0	8 months	+	+	Flexion 10°—Abduction 5° Rotation neutral Shortening 1 cm.	Excellent	5 years
	Case 13	1 year 8 months	1 year 8 months	+	+	Flexion 15°—Abduction 10° Rotation neutral Shortening 1 cm.	Good	4 years 8 months
	Case 14	3 months	5 months	+	+	Flexion 20°—Abduction 10° Rotation neutral Shortening 2 cm.	Excellent	4 years 6 months
	Case 15	6 months following 2nd operation	6 months after 2nd operation	+	+	Flexion 15°—Abduction 10° Rotation neutral Shortening 1 cm. after osteotomy	Good	4 years
	Case 16	1 year postoperative	1 year	Failure	Flap absorbed. Extensive acetabular destruction 1 year after operation	Not fused	Fair	3 years 11 months

TABLE I — *Continued*

	Sex	Duration of Symptoms	Previous Operations	Age at Iliofemoroplasty	Sinus	Tissue	Subsequent Operations	Abscess
Case 17	M	2 years	0	4 years	0	+	0	0
Case 18	M	1 year	0	5 years	0	+	0	+
Case 19	M	2 years 4 months	0	9 years	0	0	0	+
Case 20	M	3 years	0	8 years	0	+	0	+
Case 21	F	1 year	0	6 years	0	+	0	0
Case 22	F	1 year 2 months	Biopsy	4 years	0	+	0	0
Case 23	M	6 months	Biopsy	9 years	1st 0 2nd 0 3rd +	+	2nd operation 6 mos. after 1st. A new iliac flap 1 yr. 6 mos. after 1st operation	1st 0 2nd 0 3rd +
Case 24	M	1 year 4 months	0	8 years	0	+	Drainage of abscess 1 yr. 9 mos. after fusion and excision of abscess wall	0
Case 25	M	9 years	Drainage of abscess	10 years	+	+	1st. Reinsertion of flap into trochanter 1 yr. after fusion. 2nd. Femoral graft interlocked with iliac flap 26 months later	1st +
Case 26	M	3 years	0	6 years	+	0	0	+
Case 27	F	5 months	Aspiration of abscess	3 years	0	Guinea-pig inoculation positive	0	0
Case 28	M	2 years	0	8 years	0	0	New flaps split from femur and ilium 3 months after 1st operation	+ at both operations
Case 29	F	4 months	0	8 years	+ over sacrum	+	0	+
Case 30	F	9 years	0	14 years	0	0	0	0
Case 31	M	1 year	0	7 years	0	0	0	0
Case 32	F	7 years	Biopsy	13 years	0	+	0	0
Case 33	F	1 year	0	2 years 2 months	0	+	0	0

TABLE I—*Continued*

	Drainage	Period of Immobilization After Operation	Clinical Fusion	X-Ray Fusion	Position-Shortening	Nutrition	Time Since Fusion
Case 17	3½ years	3½ years	+	+ 2 years; 4 months after iliofemoroplasty	Flexion 20°—Abduction 10° Ext. rotation 30° Shortening 2 cm.	Dead 3½ years after iliofemoroplasty of generalized tuberculosis	3 years 6 months
Case 18	2½ years	1 year 8 months	+	+	Flexion 15°—Abduction 10° Ext. rotation 10° Shortening 2 cm.	Good	3 years 3 months
Case 19	4 months	6 months	+	+	Flexion 15°—Abduction 10° Ext. rotation neutral Shortening 2 cm.	Good	3 years 2 months
Case 20	3 years. Still draining	3 years	+	+	Flexion 15°—Abduction 10° Ext. rotation 20° Shortening 2 cm.	Good	3 years
Case 21	6 weeks	1 year	+	+	Flexion 25°—Abduction and adduction neutral Ext. rotation 10° Shortening 1 cm.	Excellent	2 years 9 months
Case 22	0	11 months	+	+	Flexion 15°—Abduction 15° Rotation neutral Shortening 1 cm.	Good	2 years 8 months
Case 23	Drained 1½ years after 2nd operation to time of death	2 years	Failure	X-ray shows progressive destruction	Dead	Dead	2 years 5 months
Case 24	5 months	10 months	+	+	Flexion 20°—Abduction 15° Ext. rotation 30° Shortening 2 cm.	Excellent	2 years 1 month
Case 25	4 months	8 months after 3rd operation	Failure	X-rays show no fusion between flap and trochanter	Flexion 20°—Abduction 10° Rotation neutral Shortening 4 cm.	Excellent	2 years
Case 26	1 year 10 months	1 year 2 months	+	+	Flexion 20°—Abduction 15° Ext. rotation 20° Shortening 1 cm.	Good	1 year 10 months
Case 27	1 year 4 months	1 year	+	+	Flexion 20°—Abduction 10° Ext. rotation 20° Shortening 2 cm.	Good	1 year 5 months
Case 28	Draining 1 yr 4 months. Still draining	1 year 4 months. Still immobilized	Failure	Flap absorbed	Not fused	Unknown	1 year 4 months
Case 29	1 year 2 months. Still draining	11 months	+	+	Flexion 15°—Abduction 15° Rotation neutral Shortening 2 cm.	Good	1 year 2 months
Case 30	0	6 months	+	+	Flexion 15°—Abduction 10° Rotation neutral Shortening 2 cm.	Good	8 months
Case 31	0	7 months	Failure	Flap absorbed	Not fused	Excellent	7 months
Case 32	Draining 10 months. Still draining	8 months	+	+	Flexion 15°—Abduction 15° Rotation neutral Shortening 2 cm.	Excellent	10 months
Case 33	0	4 months. Still in cast	Failure	Flap absorbed	Not fused	Good	4 months

useful position. Early operation is advised and abscesses are not considered a contra-indication if sinuses are not present.

Schumm stated in 1929 that he had operated successfully upon nine cases in children.

Through a personal communication from Z. B. Adams it is possible to report that ten patients at the Lakeville Sanatorium, between the ages of three and fifteen years, suffering from tuberculosis of the hip joint, have been operated upon during the past two years by the pedicle-flap method. Five of the patients now have a solid fusion of the diseased joints.

Indications for Operation

Iliofemoroplasty is suitable for any child, irrespective of age, who is suffering from tuberculosis of the hip joint and is known to be a good surgical risk. Abscesses with or without sinuses should not dissuade one from attempting surgical ankylosis of the diseased joint. It is well to avoid the tracts or openings of the sinuses during operation to avert unnecessary dissemination of infection. Extensive destruction of the femoral head and acetabulum simplifies the pedicle-flap operation because of the ease with which the iliac flap is placed into the trochanteric cleft.

Biopsy

Fixation by extra-articular fusion must be done early if the structures comprising the joint are to be preserved. Although the history and clinical findings are indicative of a joint inflammation, the nature of the infecting agent may not be clear, and joint tissue should be removed for histological study or for animal inoculation. The function of the joint will not be jeopardized if the infection proves to be non-tuberculous. On the other hand the presence of typical tubercles in the tissue, with or without bacilli, or tuberculosis in an inoculated animal confirms a diagnosis of joint tuberculosis and justifies immediate fusion.

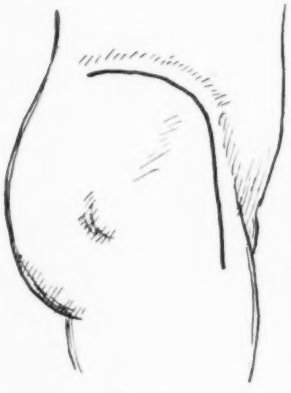

FIG. 1
Line of incision.

Description of Operation

Iliofemoroplasty was evolved as the result of unsuccessful attempts to ankylose hips by the intra-articular method and later by autogenous tibial and fibular transplants. Tibial transplants fused to the ilium promptly, but failed to unite with the femur. The fibula fused to the ilium, but the shaft of the bone was absorbed. This was attributed to the fact that the entire shaft was used as a transplant. The absence of raw surfaces may have inhibited revascularization of the graft.

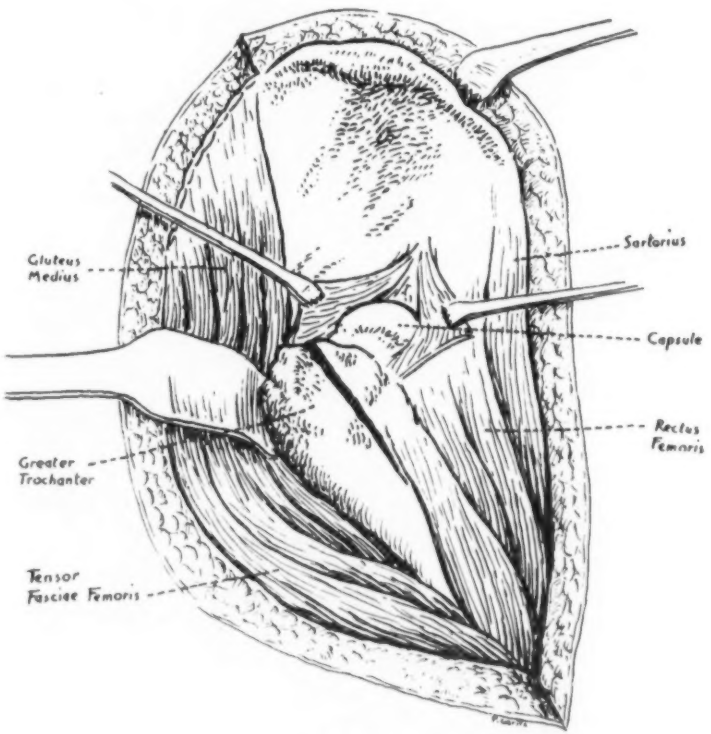

FIG. 2

Gluteus medius and minimus retracted, capsule opened, ilium exposed, and greater trochanter and shaft of femur split.

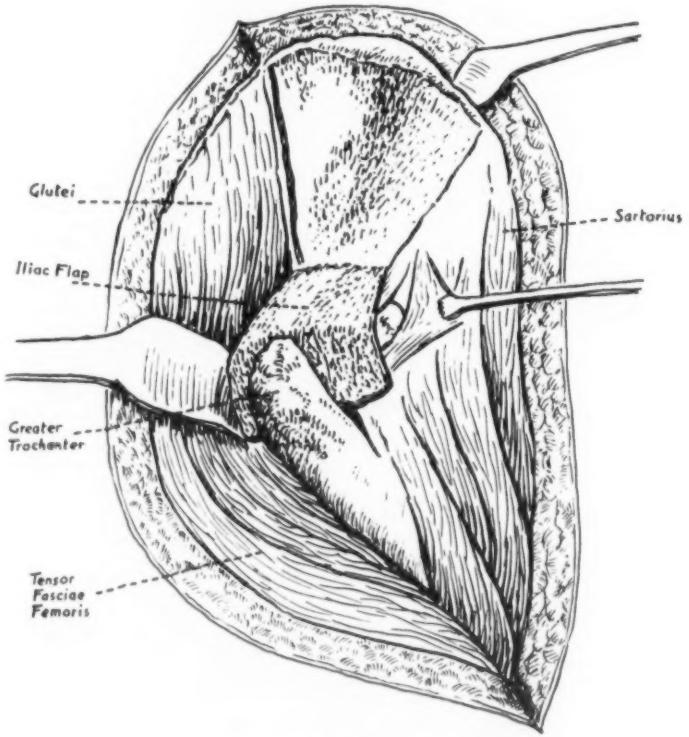

FIG. 3

Iliac flap inserted into trochanteric cleft.

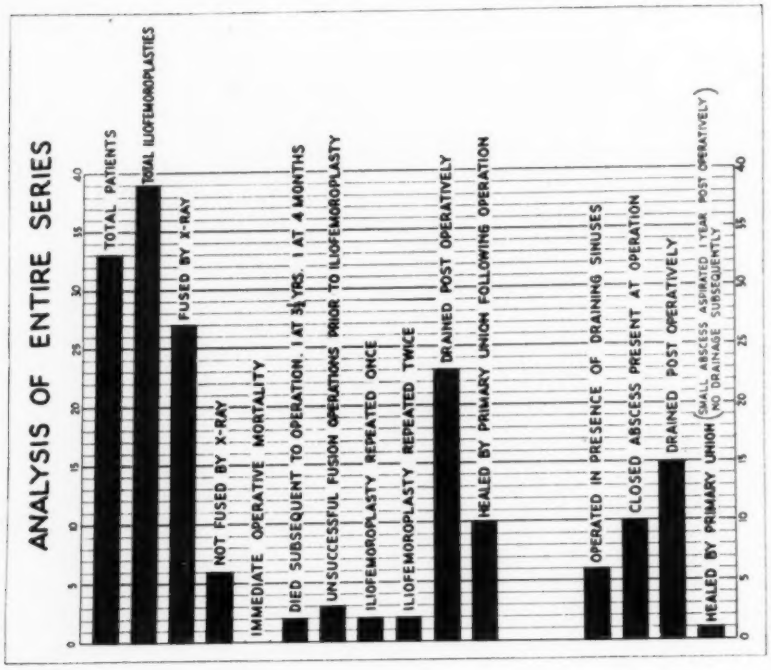
ANALYSIS OF ENTIRE SERIES
TOTAL PATIENTS
TOTAL ILIOFEMOROPLASTIES
FUSED BY X-RAY
NOT FUSED BY X-RAY
IMMEDIATE OPERATIVE MORTALITY
DIED SUBSEQUENT TO OPERATION, I AT 3½ YRS. I AT 4 MONTHS
UNSUCCESSFUL FUSION OPERATIONS PRIOR TO ILIOFEMOROPLASTY
ILIOFEMOROPLASTY REPEATED ONCE
ILIOFEMOROPLASTY REPEATED TWICE
DRAINED POST OPERATIVELY
HEALED BY PRIMARY UNION FOLLOWING OPERATION
OPERATED IN PRESENCE OF DRAINING SINUSES
CLOSED ABSCESS PRESENT AT OPERATION
DRAINED POST OPERATIVELY
HEALED BY PRIMARY UNION (SMALL ABSCESS ASPIRATED I TEAM POST OPERATIVELY) NO DRAINAGE SUBSEQUENTLY

FIG. 5

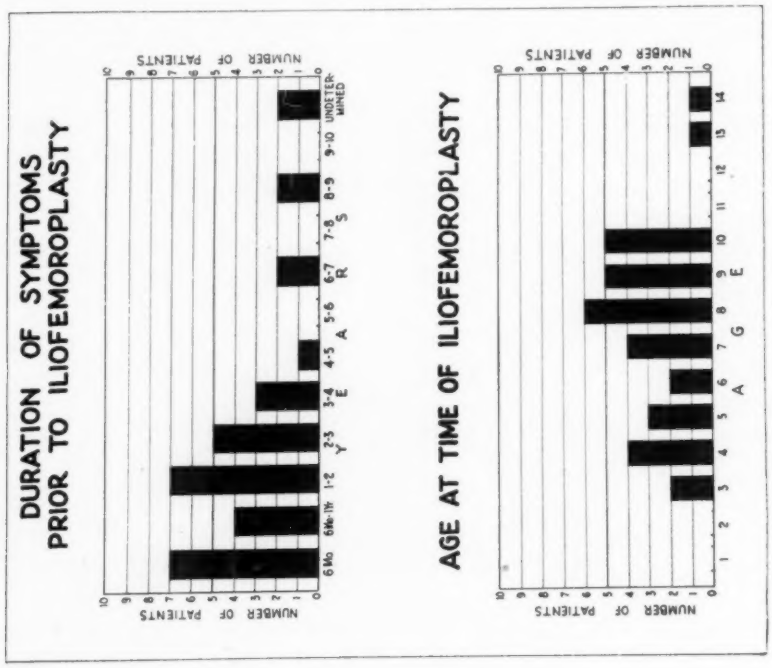
DURATION OF SYMPTOMS PRIOR TO ILIOFEMOROPLASTY
NUMBER OF PATIENTS
6 Mo 6Mo-1Yr 1-2 2-3 3-4 4-5 5-6 6-7 7-8 8-9 9-10 UNDETERMINED
YEARS
AGE AT TIME OF ILIOFEMOROPLASTY
NUMBER OF PATIENTS
AGE

FIG. 4

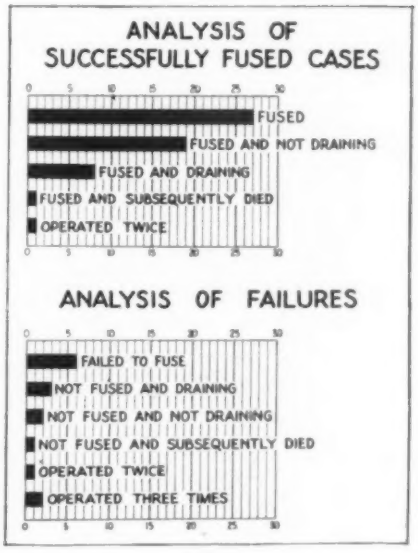
ANALYSIS OF
SUCCESSFULLY FUSED CASES
0 5 10 15 20 25 30
FUSED
FUSED AND NOT DRAINING
FUSED AND DRAINING
FUSED AND SUBSEQUENTLY DIED
OPERATED TWICE
0 5 10 15 20 25 30
ANALYSIS OF FAILURES
0 5 10 15 20 25 30
FAILED TO FUSE
NOT FUSED AND DRAINING
NOT FUSED AND NOT DRAINING
NOT FUSED AND SUBSEQUENTLY DIED
OPERATED TWICE
OPERATED THREE TIMES
0 5 10 15 20 25 30

FIG. 6

The capsule of the hip joint is exposed through a liberal anterolateral incision. The muscular attachments to the great trochanter are freed with a blunt dissector. The epiphysis of the trochanter must be displaced if it has not ossified, because if cartilaginous it endangers the nutrition of the bone flap. The shaft of the femur should then be exposed for a distance of about six centimeters. This will aid in the preparation of the trochanteric cleft. The joint capsule is split on its superior aspect, the anterior superior attachment to the ilium freed and well retracted. The great trochanter is next split for a distance of five centimeters in the longitudinal axis of the femur. A very thin osteotome is used to reflect a fan-shaped section of the outer cortex of the ilium, the base of the fan just above the margin of the acetabulum remaining attached. By exercising a little caution the flap may be turned into the trochanteric cleft by bending the pedicle. This is especially true in young children, as the bone is very flexible and not easily broken. A greenstick fracture of the flap happens occasionally, but the blood supply is not necessarily interrupted.

Since the periosteum of the ilium is removed with the gluteal muscles, replacement of the muscle flap brings the periosteum and fresh bone surfaces in contact. A solid pyramidal section of bone is the result, the neck of the femur forming the base of the pyramid.

After closure of the wound the patient is placed in a previously prepared, well dried and warmed, bivalved, long, double spica cast.

Postoperative Care

Postoperative convalescence may not differ from that following any other bone or joint operation. Wounds of ten patients healed by primary union. In seventeen of the patients who did not have sinuses at operation the wounds subsequently drained. Abscesses were encountered at operation in ten of the seventeen. The general reaction to the dissemination of infection was not great, and, although there was a considerable variation between morning and evening temperatures, the patients showed no severe toxic symptoms from the treatment.

The convalescence of the patients in whom fusion was done in the presence of draining sinuses may be made less difficult by preparing for dressings at the time of operation. The discharge from old sinuses must

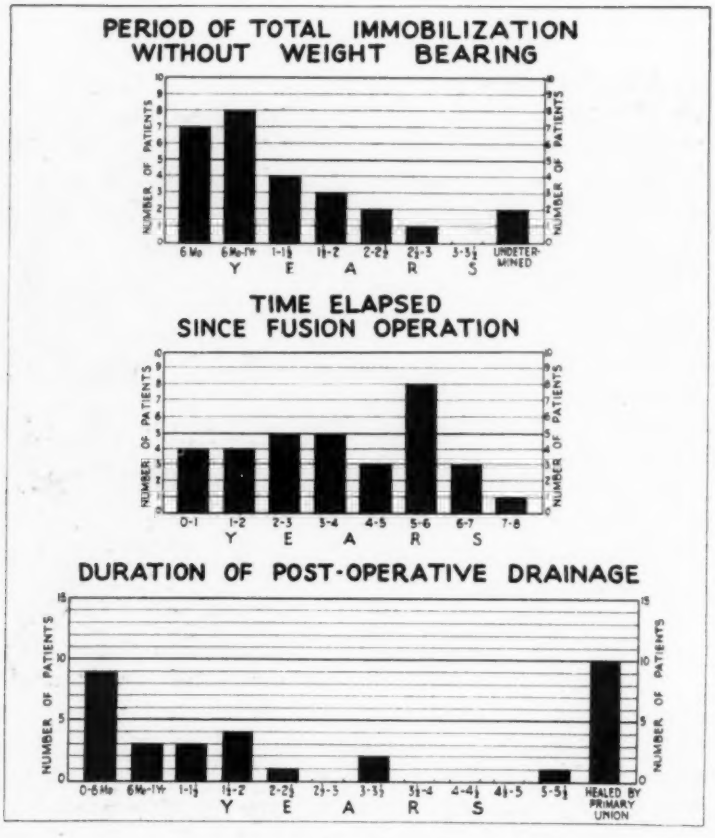

FIG. 7

not contaminate the operative wound. The septic temperature curves, which lasted in one instance (Case 20) as long as six months, are indicative of the severe febrile postoperative reactions which occurred in four of the patients operated upon in the presence of abscesses or draining sinuses. It was noted that the drainage was of shortest duration in those patients having one or more sinuses which drained posteriorly through the buttock or thigh.

No definite rules may be laid down for the length of postoperative immobilization and recumbency. In general, it is thought best to keep the fused hip fixed in a double spica until union is clinically firm. This is not an infallible dictum and was modified in certain cases, free from pain or muscle spasm, where a few degrees of motion existed. Weight-bearing with the hip protected by a short spica hastened bony ankylosis of the diseased joint in these particular instances. All hips were protected until fusion could be demonstrated by x-ray. Other measures—such as sunshine, fresh air, cod-liver oil, and heliotherapy—are invaluable adjuncts, for after all joint tuberculosis is a local manifestation of a constitutional disease.

FIG. 8-B
Case 9

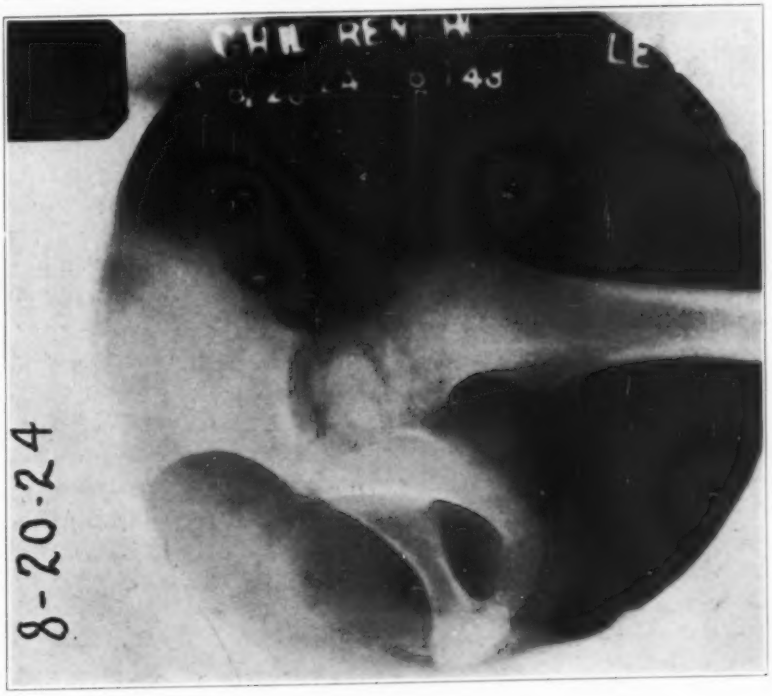

FIG. 8-A
Case 9

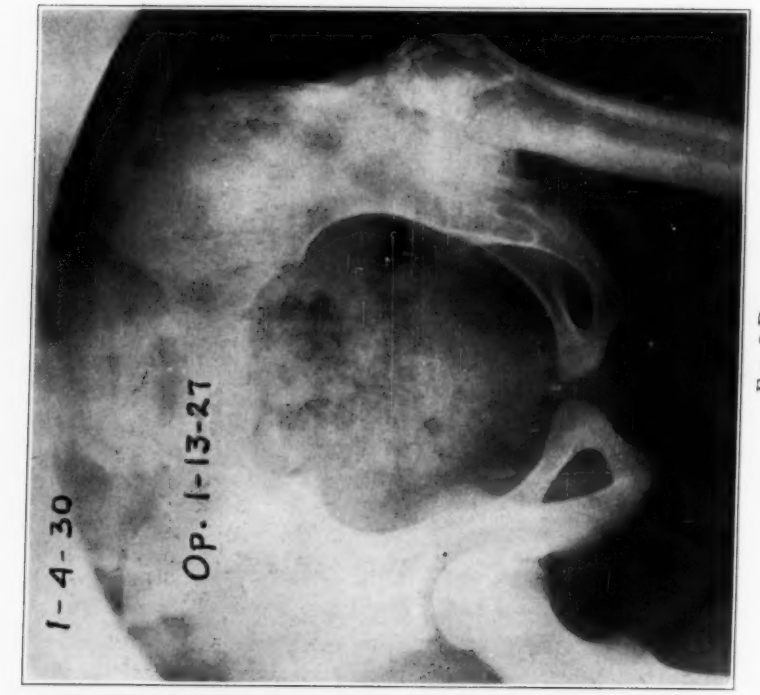

Fig. 8-D
Case 9

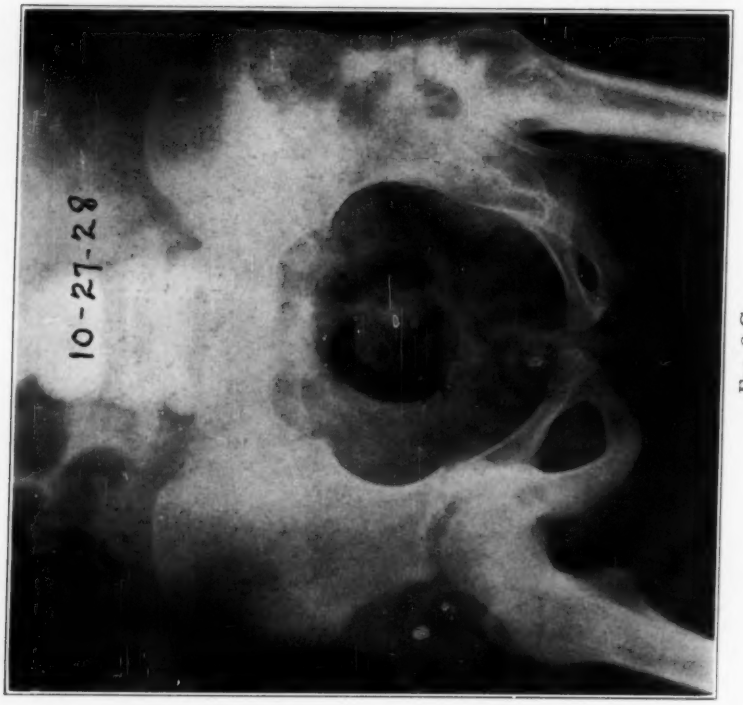

Fig. 8-C
Case 9

FIG. 8-F
Case 9

FIG. 8-E
Case 9

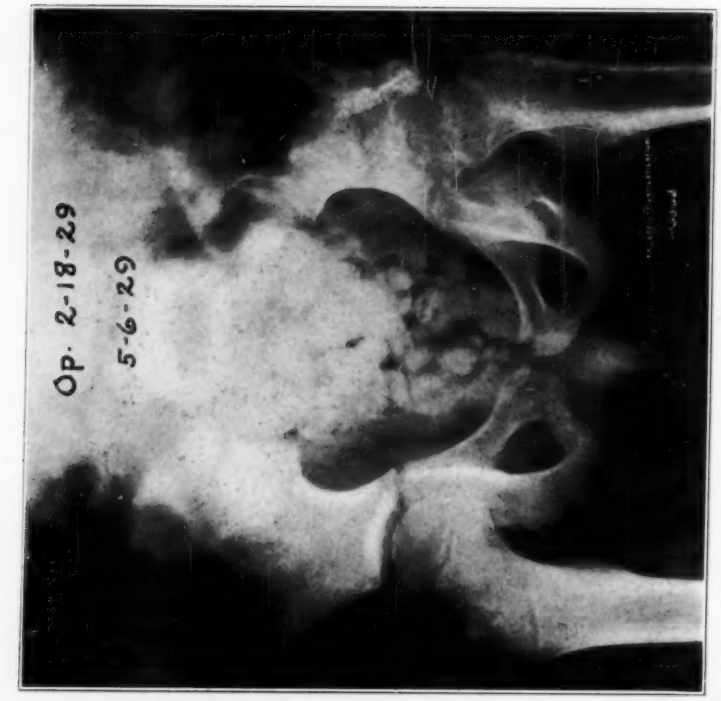

FIG. 9-B
Case 19

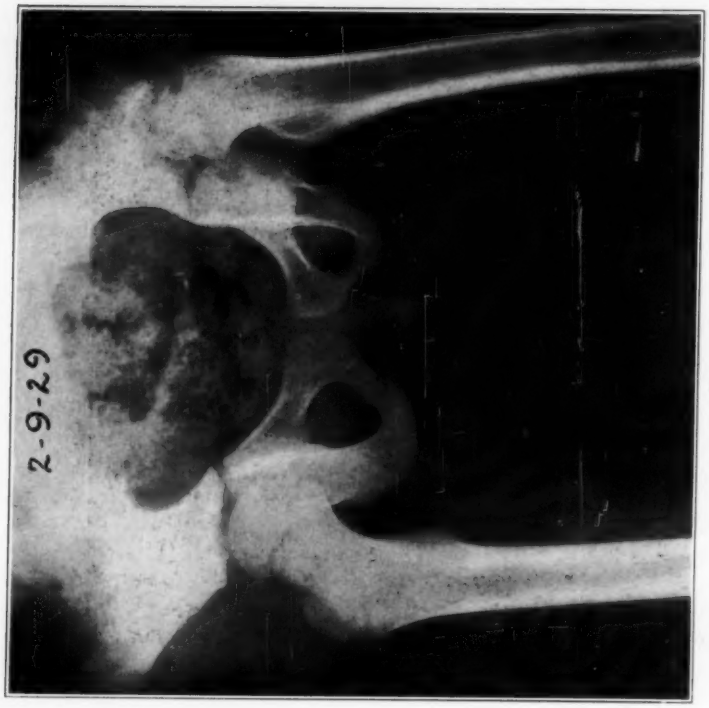

FIG. 9-A
Case 19

FIG. 9-D
Case 19

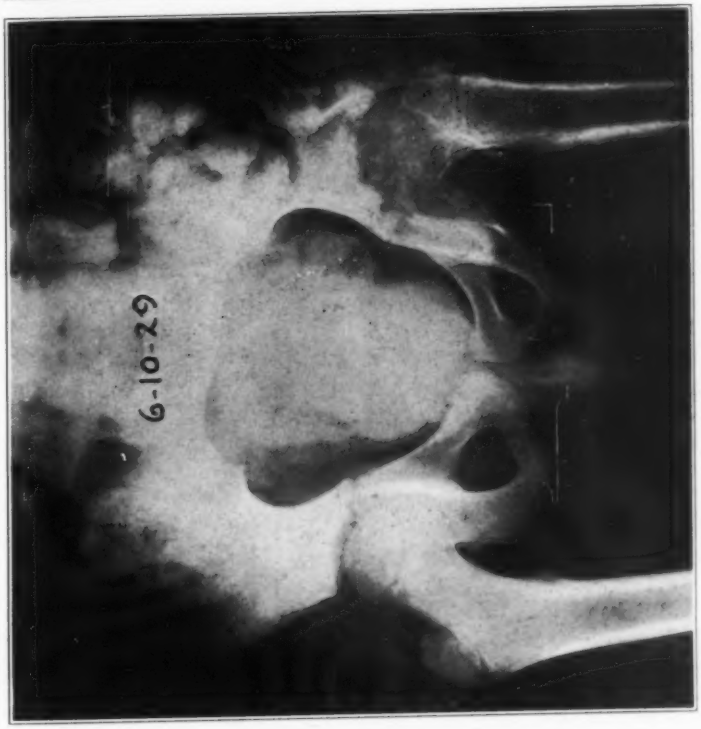

FIG. 9-C
Case 19

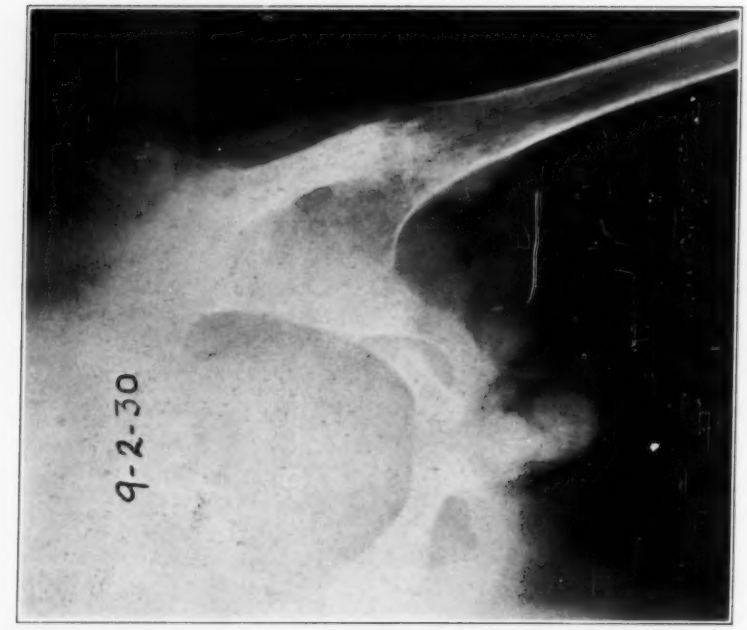

FIG. 10-B
Case 24

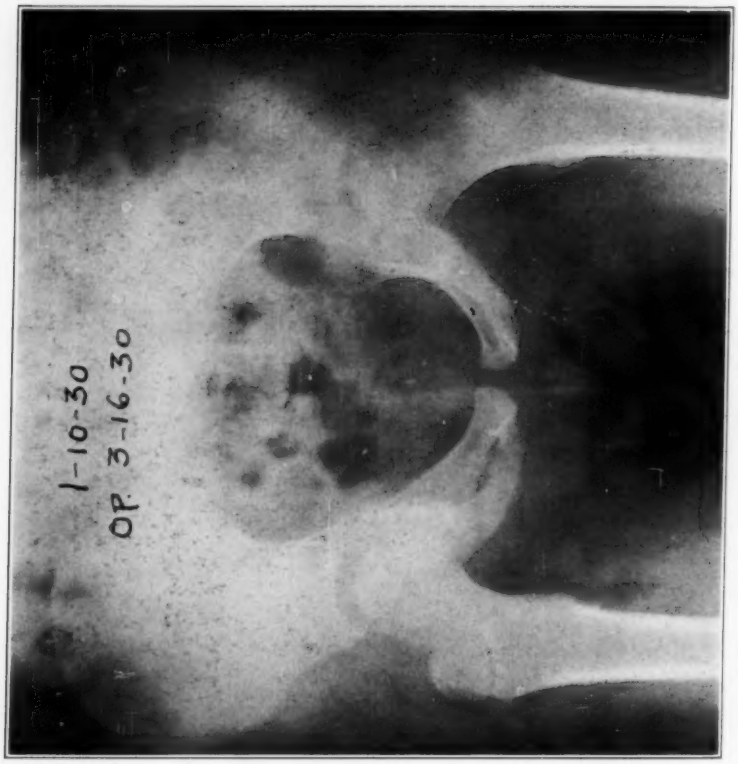

FIG. 10-A
Case 24

FIG. 10-C
Case 24

FIG. 10-D
Case 24

Age and Sex

The youngest child in this series was three and the oldest fourteen years of age. Sixteen females and seventeen males were affected, indicating that sex did not influence the development of the disease.

Previous Treatment

Conservative treatment of some sort had been given to all of these patients, but in most cases it had not been efficiently carried out. While one patient (Case 26) had been in an institution, supposedly immobilized by traction for two years, there was no evidence that this treatment was effective. A study of the x-rays taken during traction showed a rapid progression of the disease. An unsuccessful attempt had been made to fuse the hip in Case 4 by an extra-articular fibular transplant. An erosion of the cartilage of the acetabulum and head of the femur did not cause an ankylosis of the joint in Case 9. A fibular strut fused solidly to the ilium in Case 14, but absorbed at the point of trochanteric implantation. A second attempt to produce fixation of the hip by reimplanting the graft into the great trochanter was unsuccessful.

Sinuses

Discharging sinuses are not a contra-indication to the pedicle-flap operation. Six of the patients who are included in this report were operated upon in the presence of draining sinuses.

FIG. 11-A
Case 27

Tissue Examination

No cases of doubtful diagnosis were fused without a confirmation of the existence of tuberculous disease of the hip joint by microscopic examination of tissue or by animal inoculation. The presence of joint tuberculosis was verified by microscopic tissue examination in nineteen cases, and by guinea-pig inoculation in one case.

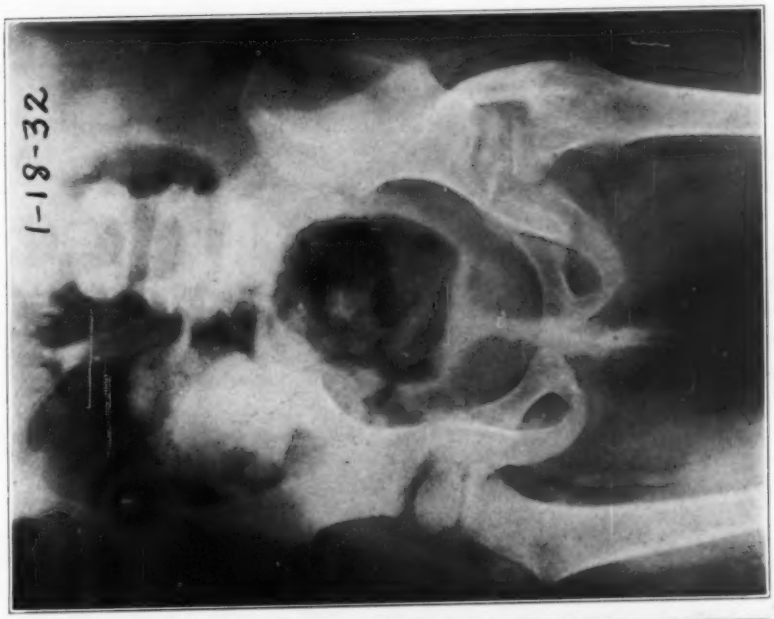

Fig. 11-C
Case 27

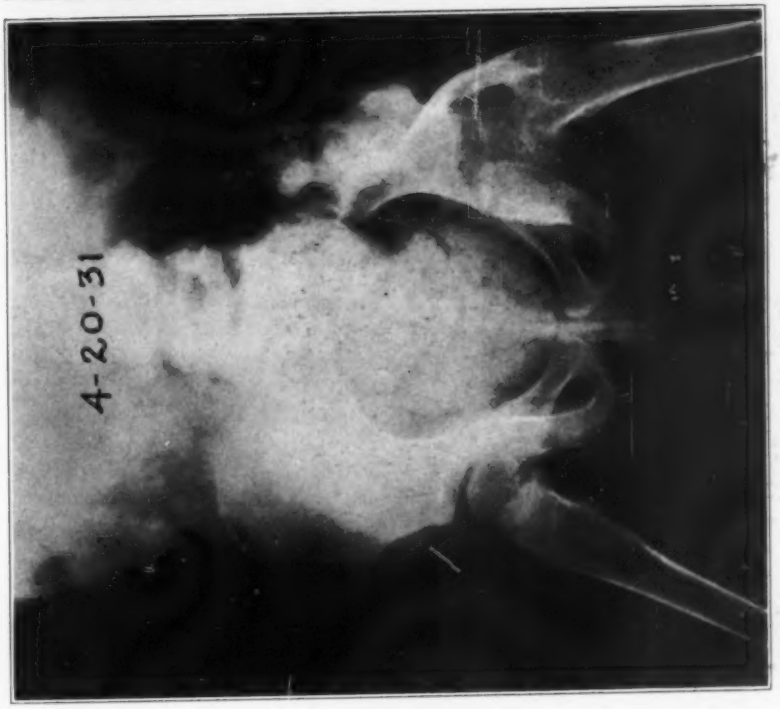

Fig. 11-B
Case 27

Subsequent Operations

A cold abscess over the greater trochanter was aspirated one year and eight months following the fusion operation in Case 12. This abscess cavity did not refill after the aspiration. A subtrochanteric osteotomy was done four years and eight months after iliofemoroplasty to correct a flexion and adduction deformity of the thigh. In Case 15 a second operation was done seven months after the first; a new graft was turned down from the ilium. In Case 23 it was certain, six months after the first operation, that the hip would not fuse. A second iliofemoroplasty was then done, and the graft again absorbed. A third fusion was attempted one year and six months after the first operation. This patient died four months later of miliary tuberculosis without a fusion of the hip joint.

In Case 24, while apparently in the best of health, the patient developed a large abscess between the skin and deep fascia one year and nine months after a fusion operation, and eleven months after solid ankylosis of the joint. The cavity was injected with lipiodol solution for

Fig. 12-A
Case 29

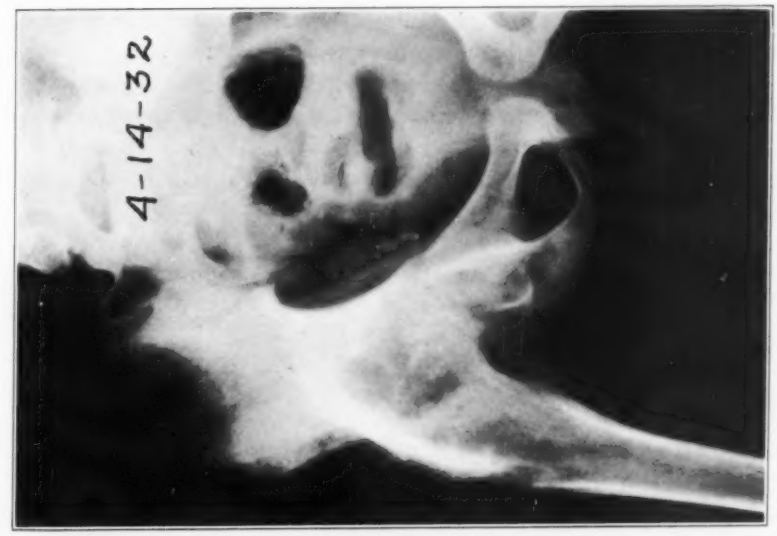

Fig. 12-C
Case 29

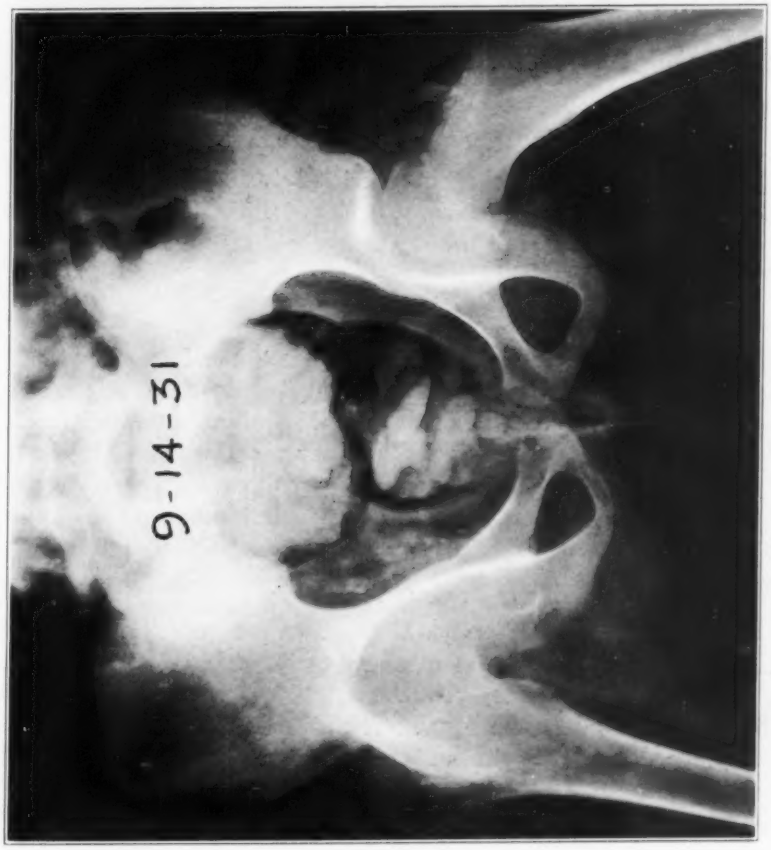

Fig. 12-B
Case 29

x-ray examination, but no connection could be demonstrated between the abscess cavity and the hip joint. The wall of the abscess was carefully excised and the wound healed by primary union. Microscopic examination of the wall of the abscess showed typical tubercles. The iliac flap was reinserted into the trochanter one year after the first operation in Case 25; this did not produce fixation of the joint, so that a femoral graft was interlocked with the flap from the ilium two years and two months after the initial operation.

A second iliofemoroplasty was done in Case 28 three months after the first operation, because x-ray examination indicated a complete absorption of the flap without any apparent healing of the diseased area.

Abscesses

Closed abscesses were encountered outside of the hip-joint capsule in ten patients. They varied in size, holding from thirty to two hundred cubic centimeters of pus. The exudate was carefully wiped away with as little contamination of the wound as possible, and disregarded in the later steps of the operation. No abscess was found in Case 23 at the first and second operations, but a definite abscess was present at the time of the third attempt at fusion which also terminated in a failure. Abscesses were found at both operations in Case 28.

Postoperative Drainage

Twenty-three of the operative wounds failed to heal by primary union. The duration of the drainage period has varied from six weeks (Case 21) to five years and three months (Case 9). In fact, Case 9 is not healed at the present time, but the hip is firmly ankylosed, and the child is in excellent physical condition.

Period of Immobilization

The shortest period of immobilization in the successful cases was five months (Case 14) and the longest three years (Case 20). Seven patients were immobilized in plaster for six months or less; eight patients for more than six months but not exceeding one year; seven patients were in plaster for more than one year but not exceeding two years. Three patients required immobilization for more than two years but less than three years. The length of the period of fixation could not be determined in two cases.

Clinical Ankylosis and X-Ray Fusion

A definite line of distinction has been drawn between clinical fixation of the joint and fusion as demonstrated by x-ray. Many of the patients were clinically well before complete consolidation of the diseased area could be demonstrated by the x-ray. The hips of twenty-seven patients are solidly fused by both clinical and x-ray examination. The graft absorbed in Case 16, and a marked increase in the destruction of the acetabulum may be seen in the x-ray films taken one year following the pedicle-flap operation. In Case 23 the patient died two years and five

months after the second operation without obtaining ankylosis of the hip. Case 25 is in excellent physical condition; there is no pain in the hip, but the hip joint allows a few degrees of motion. This case has been classified as a failure. The x-ray showed absorption of the flap in Case 28 one year and four months following the operation. Case 31 by x-ray showed absorption of the flap in seven months and Case 33 in four months.

Position of Ankylosis

A careful study of the patients with regard to gait, walking, standing, and sitting indicates that the best functional result is obtained when the hip is flexed in a position of fifteen to twenty degrees of flexion, with not more than ten degrees of abduction and without internal or external rotation. It may be necessary to modify this statement after another ten years have elapsed and these children reach adult life.

Failure to correct the external rotation of the thigh, allowing the hips to fuse with as much as thirty degrees of outward rotation, has occurred too frequently in this group of patients.

The shortening is apparently determined by the amount of epiphyseal destruction at the time of fusion. There is no evidence to indicate that the growth of the femur is retarded by fusion. Rapid healing of the disease aids growth by preservation of the remnants of epiphyseal cartilage. The greatest amount of shortening (10 centimeters) was found in Case 9 which exhibited extensive bone destruction as seen by x-ray, and many discharging sinuses. Two centimeters is the average amount of shortening and is readily corrected by holding the foot in a little equinus, or with a lift on the heel of the shoe. Structural scoliosis has not been found in these patients, despite the fact that very few are wearing shoes to correct the pelvic obliquity.

Complications

Complications of consequence developed in two cases following healing of the tuberculous focus in the hip. Case 6 returned to the clinic two years after the hip was healed for treatment of a stiff neck which proved to be caries of the cervical spine. It is not considered probable that the hip acted as a focus for the new infection. This seems to emphasize the necessity for constitutional treatment to securely encapsulate infected bronchial or mesenteric glands.

Case 24 returned to the hospital with a large soft-tissue abscess in the thigh one year and nine months after the hip was thought to be healed. This tuberculous lesion responded so readily to complete excision that it was attributed to a slowly developing focus transplanted during the operation.

Elapsed Time Since Arthrodesis

Eight years have elapsed since the first hip was fused by the pedicle-flap method. Three patients have been under observation seven years, eight for six years, three for five years, five for four years, five for three

years, four for two years, and four for one year or less since the fusion operations were done.

CONCLUSIONS

This report must be considered in the light of a preliminary study. The number of patients observed is not sufficiently great to warrant positive statements relative to the healing of bone and joint tuberculosis. An additional ten to fifteen years of observation will be essential before it can be definitely recommended that all tuberculous hips in children should be fused in a position of fifteen degrees of flexion and ten degrees of abduction.

It is believed that early fusion of tuberculous joints conserves the growing elements of bone, thereby eliminating the disability due to shortening.

Hibbs's observation, that fusion of the bone flap or strut is followed by consolidation of the diseased area, has been confirmed.

Joint tuberculosis will heal rapidly when motion is eliminated. This may be successfully accomplished by iliofemoroplasty. Draining sinuses are not a contra-indication to iliofemoroplasty. The sinuses will close when the bone and joint lesion is healed. Secondary infection is of no practical importance so far as the operation itself is concerned. The general physical condition of the patient is uniformly good after ankylosis of the diseased joint takes place.

Iliofemoroplasty is not a difficult technical procedure and it may be done without danger to life.

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A REPORT OF SEVENTEEN CASES OF TUBERCULOSIS OF THE HIP FUSED BY THE WILSON METHOD

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Lakeville State Sanatorium

After having attempted more than a dozen fusions of tuberculous hips according to the Hibbs method, with rather unsatisfactory results in the majority of cases, a different surgical procedure was desired.

In 1927 Dr. J. C. Wilson suggested an operation for fusing tuberculous hips which he described as an "Ilio-Femoro-Plasty".[1]

In 1930 Dr. Z. B. Adams, our orthopaedic consultant at Lakeville State Sanatorium, adopted this method of fusing tuberculous hip joints. He has modified it, however, by approaching the hip joint through an anterolateral incision and by leaving the entire capsule intact, rather than incising it parallel with the neck of the femur as in Wilson's operation. Thus the operation, as performed at this institution, is a complete extra-articular one and is attended with very little danger of incising a tuberculous focus.

This operation is primarily indicated in children up to twelve years of age, as the bone in children is more flexible and will bend easily, whereas in adults the bone is brittle, and the iliac flap is apt to break off at its attachment as it is bent downward on itself to be inserted into the trochanter. Our youngest patient was four years old and the oldest eighteen.

Up to date this method of fusion has been tried in seventeen cases. We have been able to follow thirteen of them and each one has resulted in a completely ankylosed and painless hip joint. The last four cases have been done very recently and have not yet come out of plaster. These hips have, therefore, not yet been examined for results.

It will be noted from the chart that three of the cases also had other forms of surgical fusion with unsatisfactory results. The Wilson fusion was done after the previously attempted fusion and in all three cases ankylosed hip joints resulted. One death is recorded in this series. This patient died of generalized tuberculosis and at autopsy was found to have extensive processes in the chest, spine, tubes, uterus, and ovaries in addition to her hip and knee involvements. The hip was examined at autopsy, which was eight months after operation, and was found solid with a good, thick bone block. The knee was also solid.

The time required for this operation is about forty-five minutes, and the plaster is applied immediately after the operation, while the patient is coming out of ether; the leg is held in fifteen degrees' abduction and about thirty degrees' flexion. Dr. Wilson found it necessary to place his patients in plaster shells after the operation, thereby lessening the time and avoiding shock from wet casts. We have practically no complications of shock, even with patients who have been confined to bed for two

TABLE I

	Name	Age	Lesions	Duration of Hip Lesion	Operations	Results
Case 1	W. S.	8	Tbc. hip, left	4 years	Wilson	Hip solid on discharge (14 months after operation)
Case 2	E. D.	12	Tbc. hip, right	10 years	Arthrodesis before admission Wilson 14 months after admission	13 months later, motion present 16 months after operation, hip solid
Case 3	B. P.	18	Tbc. hip, left	3 years	Hibbs fusion 2 years after admission Wilson 4 years after admission	20 months later, motion present 10 months later, hip solid
Case 4	S. G.	11	Tbc. hip, right	16 months	Wilson, Apr. 1931	Hip solid, Aug. 1932
Case 5	M. M.	18	Spine, 12D-1L Tbc. hip, right Tbc. knee, right	3 years	Excision of knee joint, Nov. 1928 Wilson, Apr. 1931	Patient died of generalized tuberculosis At autopsy hip was solid
Case 6	F. F.	18	Tbc. hip, right	5 years	Hibbs, Feb. 1930 Wilson, Nov. 1931	Motion present Hip solid, Aug. 1932
Case 7	E. C.	8	Potts' disease Hilum and abdominal tuberculosis Tbc. hip, left	Since 20 months of age	Wilson, June 1931 Albee spinal graft, Apr. 1932	Hip solid, Aug. 1932
Case 8	A. B.	4	Tbc. hip, left	1 year	Wilson, May 1931	Hip solid, Aug. 1932
Case 9	A. S.	7	Tbc. hip, left hilum	2½ years	Wilson, Sept. 1931	Hip solid, Aug. 1932
Case 10	T. M.	6	Tbc. hip, left	2 years, 10 months	Wilson, Nov. 1931	Hip solid, Aug. 1932
Case 11	B. S.	10	Potts' disease Tbc. ulna, right Tbc. hip, right	1½ years	Saucerization of ulna, Nov. 1931 Wilson, Nov. 1931	Ulna healed Hip solid
Case 12	G. T.	10	Tbc. knee, left Tbc. hip, left	Since 2 years old	Wilson, Nov. 1931	Hip solid, Aug. 1932
Case 13	A. B.	14	Tbc. hip, left	2 years	Wilson, Jan. 1932	Hip solid, Aug. 1932
Case 14	N. J.	7	Tbc. hip, right	4 years	Wilson, Apr. 1932	Still in plaster
Case 15	M. Z.	7	Tbc. spine Tbc. hip, left	4 years	Wilson, May 1932	Still in plaster
Case 16	W. W.	6	Tbc. hip, right	3 months	Wilson, June 1932	Still in plaster
Case 17	T. D.	7	Tbc. hip, right	2 years	Wilson, July 1932	Still in plaster

Note: Since this paper was submitted for publication, Cases 14 and 15 have been examined and the hips were found to be solid.

years or more. Our rule is to allow the patient up and about on crutches for at least two months previous to operation. We also avoid operating in the presence of sinuses. After operation the patient is kept in bed for four to six months with plaster fixation and is then allowed up in a single short spica and allowed to bear weight.

SUMMARY

1. Seventeen cases of tuberculous hips have been fused by a modified extra-articular and extracapsular iliofemoroplasty, as first described by Dr. J. C. Wilson.

2. Complete ankylosis was obtained in all of the thirteen completed cases.

3. The advantages of this type of fusion are that the operation takes less time; it does not enter the tuberculous joint, and it gives very satisfactory results. We have had no postoperative sinuses, no complications, and no failures.

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COMBINED INTRA-ARTICULAR AND EXTRA-ARTICULAR ARTHRODESIS FOR TUBERCULOSIS OF THE HIP JOINT *

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The thirty-seven cases which form the basis of this report are presented as evidence that fusion of the hip joint by arthrodesis for tuberculosis deserves the general recognition it has received. I shall compare as fairly as can be done in a limited series the intra-articular type of operation, the extra-articular type, using some form of bone grafting, and what might be called a combined operation in the course of which thorough removal of tuberculous tissue is done and in addition a bone graft is used. These patients were taken care of in The Mayo Clinic between 1919 and 1931 inclusive. I do not intend to review the literature on tuberculosis of the hip, although I am well aware of the large amount available, but reports of operative end results, comparisons of methods, and considerations of operative complications are not common.

SUMMARY OF CASES

Twenty-one (56.7 per cent.) of the patients were males and sixteen (43.3 per cent.) were females; the right hip of twenty (54 per cent.) was involved and the left hip of seventeen (46 per cent.). The ages ranged from nine to forty-eight years. There were two patients in the first decade of life, twelve in the second, fifteen in the third, four in the fourth, and four in the fifth; twenty-seven (73 per cent.) were between the ages of ten and thirty years.

The symptoms had existed from five months to forty years. In four cases symptoms had been present for less than one year, in nine for two to five years, in seven for six to ten years, in ten for eleven to twenty years, in four from twenty-one to thirty years, and in three from thirty-one to forty years. A definite familial history of tuberculosis was obtained in seven (19 per cent.) of the cases.

Trauma seemed to be reasonably under suspicion as a factor in fourteen cases (38 per cent.); this is rather a high figure, although the period of time between the sustaining of the trauma and the definite development of the disease ranged from a few days to a year. However, the personal equation must necessarily enter into this phase of the subject.

In five cases (13.5 per cent.) there was a history of contact of the patient in a fairly intimate way with some others who had open pulmonary tuberculosis.

Operation was performed on thirty-four patients (92 per cent.) in the chronic stage of the disease; on one patient (3 per cent.) in the subacute

* Read before the American Orthopaedic Association, Toronto, Ontario, June 16, 1932.

stage and on two patients (5 per cent.) in the acute stage. The joint fused satisfactorily in the patients in the acute stage,—one in three months without drainage, and the other in eight months with drainage for the same period.

It seemed to me that the treatment previous to operation had been sufficiently adequate and good in eleven cases (30 per cent.), and the condition of the patient at the time of operation could not fairly be attributed to neglect or improper treatment. In twenty-six cases (70 per cent.), however, the conservative treatment accorded could not be considered at all satisfactory.

The general condition of the patients at the time of operation was good in twenty-one cases (56 per cent.), fair in fifteen (40.5 per cent.), and poor in one case. Tuberculosis elsewhere than in the hip joint was found in nine cases (24 per cent.). In six cases the lungs were involved, in two the spinal column, and in one case the spinal column and testis were involved. These conditions, however, were sufficiently quiescent to permit operation on the hip and in none caused any concern after the operation.

In all cases the patients complained of pain; the limb was shortened by an average of four and seven-tenths centimeters. In six cases there were healed scars of previously draining sinuses. Draining sinuses should be considered a contra-indication to arthrodesis; such sinuses were not present in any of our cases. Deformity caused by flexion and adduction was present in more than half the cases, but no appreciable deformity was present in seven. Atrophy of the thigh was present in all. The common change noted in the roentgenograms was atrophy of the bone, and in ninety-one per cent. the destructive changes were in the head of the femur and acetabulum. In two cases there were changes in the head and neck of the femur only, and in one case in the acetabulum only.

Definite information concerning the end result in thirty-six cases has been received. In the single case classified as undetermined with regard to result, the patient was dismissed in good condition, still wearing a cast at the end of three months, but has not been heard from. Another patient, a boy, aged thirteen years, in progressively poor general condition at the time of operation, although organic disease or tuberculosis was not demonstrable elsewhere, died of generalized miliary tuberculosis seventy days after an extra-articular operation to effect fusion by bone graft. Thus we have thirty-five patients concerning whom we have enough definite data to base an opinion as to the result of the particular type of operation performed.

At the time of operation, tissue from nineteen of the thirty-seven patients was submitted to the pathologist for microscopic examination. The condition in thirteen cases was reported positively as tuberculous, but in six, inflammatory changes only were distinguished histologically. In all, however, the clinical diagnosis was, without equivocation, tuberculosis, and the destructive process causing disintegration of the structures

of the joint was so evident at operation that the surgeon did not feel the necessity of pathological corroboration of the diagnosis and proceeded without delay with the arthrodesis. In three cases inoculations of guinea pigs were resorted to, and in all reactions were positive. In one of these cases at the time of operation histological examination of the tissue had disclosed only inflammatory changes. Therefore, in the series there are fifteen cases (40 per cent.) of tuberculosis, definitely proved by microscopic examination of the tissue removed, by inoculation of guinea pigs, or by both. The remaining twenty-two cases have been carefully selected because of the clinical history, the observations on physical examination, and the pathological changes seen at the time of operation, all pointing directly to tuberculosis as the cause of the destructive arthritis.

TYPES OF OPERATION AND END RESULTS IN THIRTY-FIVE CASES

Formerly, there were so many failures following the ordinary attempts at intra-articular arthrodesis that the operation fell into disrepute. When the various extra-articular operations were advanced, and advocated in this country particularly by Albee and Hibbs, action was stimulated once more. Since fusion has been almost uniformly satisfactory in arthrodesis of the knee joint for tuberculosis, when all the tuberculous débris can be removed, it seems reasonable to assume that the same complete operation in the hip joint would give equally good results provided such a radical operation was not too severe, and that subsequent drainage due to involvement of the soft tissues by tuberculosis would not be too prolonged and profuse. It must be remembered that a complete and adequate extra-articular operation is not the simple mechanical procedure it might seem, that comparatively few surgeons have the skill to carry it out properly, and that not all cases are suitable for this operation. It would appear to be a more rational procedure to attack the affected part and remove the tuberculous tissue, than merely to give support and wait for nature to overcome slowly the tuberculosis within the joint and contiguous bony structures. If this operation can be done with no more risk to life, with no more frequent and prolonged drainage, and if failures are less common, then, other things being equal, the more radical operation, with removal of the affected tissue, is indicated, particularly since operation must be performed in either case.

I have used a varied type of incision, but in the main have employed the Smith-Petersen type. I have changed part of his cutaneous incision by making a long curved incision, so that the base of the resulting flap will be upward; the incision extends from several inches behind the anterior superior spine of the ilium, sweeping downward posteriorly, and toward the greater trochanter, thence curving downward and forward to several inches below the greater trochanter. This flap of skin is then dissected upward, and fastened by skin clips to the wall of the abdomen and anterior portion of the thigh, thus keeping the skin of the groin, so

difficult to cleanse, out of the operative field. The gluteal muscles are then reflected from the wall of the ilium, and the capsule of the joint is exposed. In all cases the capsule, unless already destroyed, was found to be oedematous and greatly thickened. At this point the decision must be made as to whether the operation is primarily to be extra-articular, or if the operative attack should be carried directly to the cavity of the joint itself. Bone abscesses either in the femoral head or in the acetabulum were observed in fifty-seven per cent. of the cases in which the joint was opened and the radical operation performed.

I obtain bone for a graft from the ilium, place it so that it bridges from the ilium to the greater trochanter, and wedge it in tightly, with the hip held at the elective angle at which it is to be placed in the cast. The anterior superior spine has been used as a graft in three cases after the method suggested by Ghormley. The criticism leveled at the intra-articular operation, by which the joint is radically opened, the acetabulum cleaned out, and the head of the femur freshened to secure good contact of bony surfaces, that it is more prone to cause dissemination of the tuberculosis, is I believe, not founded on facts supported by a sufficient number of cases to be acceptable. On the contrary, the present series of cases seems to refute any such charge. The various types of arthrodesis, which were considered last year before this society by Ghormley, in the main are all devised with the desire to avoid extensive exposure of the hip joint itself, aiming to obtain fusion by the aid of extra-articular bone grafts.

In the thirty-seven cases there were no postoperative infections in the ordinary sense, and no operative deaths; the only death that occurred was that of a boy, seventy days after operation, due to dissemination of infection to the lungs, and to other organs. The operation was extra-articular in type.

Intra-Articular Operation Without Bone Graft.—In only two cases was the intra-articular type of operation alone used. In one the operation was incomplete, the head not being thrown out of the acetabulum and freshened, and failure resulted. In the second case all of the affected tissue was thoroughly and completely dissected away, a number of bone abscesses were cleaned out, and the bony surfaces of the head of the femur and of the acetabulum were freshened. Union, with excellent function, resulted. There was no postoperative drainage in either case.

Combined Intra-Articular and Extra-Articular Operation With Bone Graft.—Wide exposure of the joint was made, the head of the femur was dislocated and the bony contour of the acetabulum and femoral head were thoroughly cleansed and freshened so as to expose plenty of healthy, fresh bone on each articular surface. Even at the expense of prolonging the operation a diligent attempt was made to remove as much as possible of the diseased tissue and tuberculous débris. In the more recent cases I am confident that the development of bony fusion has been hastened not only by thoroughly removing the cartilage from the bone on both

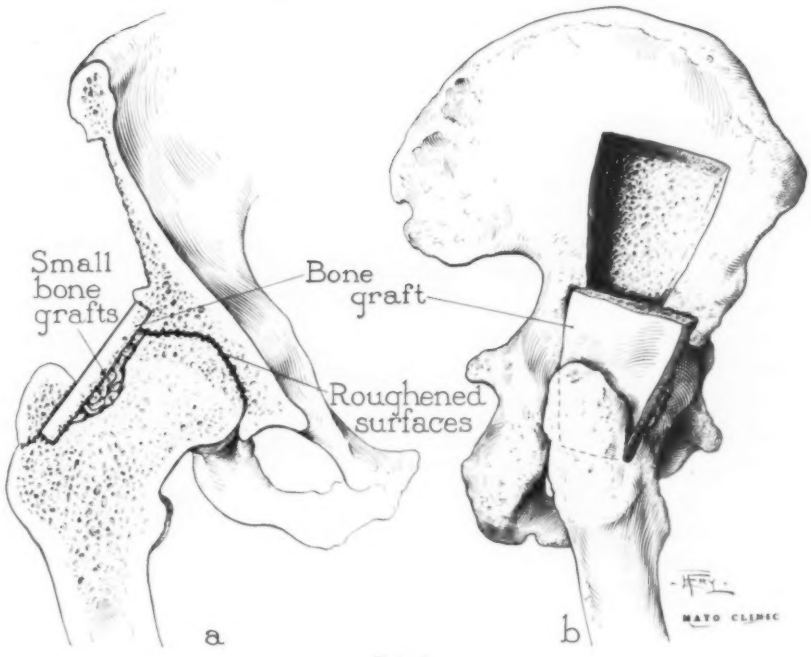

FIG. 1

a, Sagittal view of joint. *b*, Lateral view of graft.

femoral head and acetabulum, but by using a small gouge to dig up little pieces of spongy bone on both the femoral head and acetabulum (Fig. 1). When this is thoroughly done and the surfaces are shaped to fit, these little, partially detached balls of spongy bone will mesh. In addition, a bone graft obtained from the wall of the ilium is carefully wedged into the split trochanter and into the iliac wall, and beneath it, between the freshened femoral head and neck, are packed numerous small grafts of spongy bone obtained from the raw place on the ilium left by removal of the graft. These steps completed, the leg is carefully held at the angle of election, and the gluteal muscles are sewed back to the crest of the ilium just as a trap door would be closed. Nineteen patients were operated on by this method. One patient was lost track of three months after operation, and the end result is not known, leaving eighteen known results. Seventeen (94.4 per cent.) patients are known to have fused hips, with bony ankylosis and good function. Of sixteen patients, the operative notes stated that twelve joints were dry and four were wet. Of the nineteen patients, five (26.3 per cent.) had drainage postoperatively for from three to eighteen months; in one case, in which operation was done three years ago, the joint is still draining and without union. In fourteen (73.7 per cent.) the wound healed by primary intention without subsequent drainage.

Eikenbary and LeCocq[1] in 1929 reported a series of cases in which

an operation similar to that here described had been used with satisfactory results.

Extra-Articular Operation With Bone Graft.—In sixteen cases fusion was attempted by extra-articular methods. In some, the capsule of the joint was opened as in the so-called para-articular operations, in which the top part of the capsule is opened to permit access to the neck of the femur, whereas in others tuberculous pus and débris were present in soft-tissue abscesses, so that there was contact with the tuberculous material. As stated, one patient died, leaving fifteen by whom to estimate results. In two cases second operations were necessary; that is, there were seventeen operations on fifteen patients with fourteen successful, a percentage of eighty-two and three-tenths successful operations. If the two extra operations are disregarded and only the ultimate result is estimated, fusion was obtained in fourteen (93.3 per cent.). Drainage occurred in six instances, and lasted from three to twenty-four months.

COMMENT

Taking the group as a whole, thirty-two of thirty-five patients (91.4 per cent.) obtained bony ankylosis. However, if we count the two extra operations in the extra-articular group against the number of cases, the percentage would be eighty-six and five-tenths. The average length of time before union was secured ranged from three months to two years, with an average of eight and eight-tenths months. In more than seventy per cent. of the cases, healing was by first intention. In eleven cases sinuses developed and drained. This was doubtless due to dissemination of the tuberculosis. These sinuses always become infected with the ordinary pyogenic bacteria, but they do no appreciable harm, and healing occurs when the tuberculosis is overcome. In one case, in a woman of the pale, blond, thin-skinned type, with semiblue sclera, and with a familial history, an ugly breaking-down of the whole superficial wound in the heavy pad of fat over the trochanteric area occurred, and the wound drained for eighteen months, but excellent bony union resulted.

SUMMARY

Study of the end results in thirty-five cases discloses that bony fusion was secured in thirty-two (91.4 per cent.). The fact that there were no operative deaths indicates that among patients who are in good or fair general condition, a carefully conducted operation to produce arthrodesis in the hip should be advised without hesitation. From such a small series an opinion cannot be expressed as to its value for children, for there were only two patients in the first decade of life; union resulted in both cases, however. Although postoperative drainage due to dissemination of the tuberculosis to the contiguous soft parts is not a comfortable situation, and occurred in eleven of the cases, it was not as serious as might appear. Drainage followed in forty-four per cent. of cases in which there were "wet" joints and in twenty-two per cent. in

which there were "dry" joints. It occurred in a higher percentage of cases when the operation was extra-articular than it did when the combined operation was employed. I interpret this to mean that the occurrence of drainage is less if the tuberculous tissue is cleanly removed, to the best of the surgeon's ability. A purely extra-articular operation is occasionally possible, but often tuberculous tissue is encountered. The percentage of "wet" joints in the combined intra-articular and extra-articular group and in the extra-articular group was the same.

The great improvement in the general health in these patients following arthrodesis has been most striking. A stiff hip has not been an added handicap, for the hip was not only stiff before operation but was painful. More uniformly successful results have been obtained by the combined method of intra-articular and extra-articular operation together with bone graft than by any other method.

1. Eikenbary, C. F., and LeCocq, J. F.: Combined Intra-articular and Extra-articular Fusion of the Tuberculous Hip. Northwest Med., XXIX, 23, 1930.

THE TREATMENT OF OSTEOMYELITIS BY BACTERIOPHAGE *

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One of the most difficult problems confronting the modern surgeon is that of dealing effectively—and finally—with his old enemy, latent infection. For centuries men have sought an ideal treatment for infected wounds. We hear of boiling oil, incinerated toads, ashes, and natural balsams, and even sprayed perfumes and soft music. The late War made popular the Carrel-Dakin irrigations and bipp treatments. Following the War maggots came into vogue. In view of this long-continued search, it seems scarcely possible that a method of wound treatment, which may completely revolutionize all our previous concepts could be devised; yet I believe the bacteriophage to be just such a method.

Osteomyelitis is one of the most common forms of bone infection encountered by the surgeon today. Nearly everyone is familiar with the treatment of this condition proposed by Dr. H. Winnett Orr in 1923. Apparently violating the traditions of free drainage, he packed the saucerized wound with vaselin and vaselin gauze and enclosed it in a plaster cast which was left undisturbed for weeks. Soon after operation the patient's temperature dropped to normal and, upon removal of the cast, the wound was found to be covered with healthy red granulation tissue. Orr explained this startling result on the basis of rest, immobilization, and avoidance of reinfection by repeated dressings.

However, this explanation did not seem to me to entirely account for the marked success of the treatment. After close observation of several cases, I became convinced that some unusual phenomenon was taking place. D'Herelle, the Yale bacteriologist, had in 1921 discovered an ultramicroscopic parasite which appeared spontaneously in a culture of dysentery bacilli and destroyed them, thus in many instances saving the patient's life. This he called the "bacteriophage" because it lived on virulent pathogenic bacteria and completely lysed them.

In the mass of detailed bacteriological findings which d'Herelle presented, two experiments struck me as having a definite similarity to what had happened in the Orr-treated wound, and to offer a possible explanation.

In one of his earliest experiments with dysentery bacilli he added about 0.0001 cubic centimeters of bacterial culture to a young broth culture and subcultured the mixture immediately to an agar slant. Ultimately the surface of the agar was well covered with a roughened layer of the multiplying bacteria. Then, after a *long period of time*, two little islands appeared, two clear plaques perfectly circular in form where the

* Read at the Annual Meeting of the American Orthopaedic Association at Toronto, June 17, 1932. Submitted for publication July 14, 1932.

agar was bare, entirely free of all traces of the bacterial colony. D'Herelle explained this striking phenomenon by the spontaneous appearance of a bacteriophage which absolutely destroyed the bacteria with which it came in contact.

To prove this, his next step was to apply a platinum loop to the roughened surface of the agar and transfer a bit of the bacterial colony to a test tube of clear bouillon and incubate it. Within a short time, the tube was so teeming with bacteria that it was turbid and opaque. D'Herelle then transferred to this turbid culture an infinitesimal portion of one of the clear plaques on the agar slant. After a few hours, the bouillon, as if by magic, became perfectly clear and transparent, and centrifuging of the culture failed to disclose any bacteria whatsoever. Not only had all bacteria been killed, but their bodies had been lysed or dissolved.

Now if a chemical germicide had been placed in this tube or heat applied, the bacteria would have been killed, but at the bottom of the tube there would have been the dead bacterial bodies. Not so in this tube of d'Herelle's. There was not a trace of sediment. Not a dead bacterial body could be found.

Having observed this remarkable phenomenon in tube No. 1, d'Herelle took a second tube and repeated the process, except that he introduced the phage from tube No. 1 instead of from the agar slant. The result was the same—complete lysis of the bacterial bodies—showing that the phage had not lost its potency through lysing the bacteria in tube No. 1. He then took a third, fourth, fifth, and even twentieth tube, in each instance transferring a bit of bacterial colony from the agar slant and incubating it; then, when the tube was turbid with bacteria, dipping a platinum loop into the preceding tube and transferring a tiny portion of the fluid to the last tube. Each time there was the same evidence of the activity of the bacteria-destroying phage, striking proof that he was dealing with a living organism, capable of self-reproduction; for an enzyme or any non-multiplying agent would have lost its potency from extreme dilution long before it reached the twentieth tube.

D'Herelle further demonstrated by laboratory experiment that there were several varieties or "races" of phage, for the various strains of each type of bacteria, but that these also had certain destructive influences upon other strains of bacteria.

The analogy to the bacteriophage-treated wound is obvious. When one closes up the wound with a paraffin-vaselin tampon and plaster cast, it is infected and discharging pus. When one removes the dressing eight weeks later, the wound is clean and healthy. Whatever agent clears out the offending infection appears spontaneously, as on d'Herelle's slant culture, for none has been introduced. And the long lapse of time, just as in his experiment, permits this agent to carry on its bacteria-destroying action to a successful end. Is it not logical to assume that the phage principle has been working in the wound, that a native bacteriophage has multiplied and become active under the long-continued dressing?

With this working hypothesis, I immediately proceeded to use this revolutionary method in all cases of osteomyelitis, and by careful laboratory search and clinical tests, it was established that, as I had assumed, a specific phage did appear spontaneously in about ninety-four per cent. of cases of acute and chronic osteomyelitis.* In three of the remaining six per cent. in which the phage did not appear spontaneously, the laboratory has been able to supply us with a phage specific for the organism in question; but in the other three per cent. it has, so far, been unable to do so. This is especially true of the streptococcus hemolyticus, and in these cases, we have adopted a policy of watchful waiting. In several instances, the desired phage has later appeared in the wound spontaneously and healing has occurred. It is hoped that with the perfection of laboratory methods and increased knowledge of the phage, it may be possible to isolate races of phage specific for each strain of bacteria in all cases.

In cases of osteomyelitis, both acute and chronic, I now make use of the following method of treatment. I do not use alcohol or iodin as does Orr, lest they interfere either with the development of the spontaneous phage or with the specific laboratory-bred phage after its introduction.

In precisely the same way the chemical spray does more damage to the beneficial parasite than to the pathogenic pest in the orange or grapefruit groves, and therefore should not be used. One of the orchard grower's problems is how to destroy the purple scale, which kills orange trees just as bacteria kill human tissues. There are open to him two methods of combat,—he may spray his trees with a strong chemical which parallels the Carrel-Dakin treatment; or he may let a parasite fight the battle instead. This is the red-headed ray fungus, a parasite which exists in orange groves by eating the purple scale. The threads of the fungus penetrate the body of the scale and eventually kill it as well as the eggs it contains. If the fungus does not of itself arrive in the grove, the gardener may import it. For certain other pests, he may introduce lady beetles if they do not spontaneously appear, as they often do. Fruit growers now seldom spray trees with chemicals to destroy certain pests, if they can make use of a living parasite or natural enemy, for the latter method is much more reliable. In fact, some pests are completely resistant to chemical sprays and can only be eradicated by a natural enemy or parasite (phage).

The treatment of a group of cases of osteomyelitis with complications, such as infected fractures, entails a multitude of considerations. In most of these cases, we have deep wounds extending into the bone, with varying degrees of infection. The ideal wound dressing must, therefore, have a degree of solidity sufficient to restrict the tendency of the orifice at the dermis to close earlier than the depths of the wound. At the same time, this tampon should be such that it can be inserted in practically a fluid state, in order to flow uninterruptedly to every recess of the wound; it

* I am indebted to Dr. Ward MacNeal and Miss Marjorie Patterson of Post-Graduate Hospital for extensive help in this work.

should then become semi-solid, thus tending to conserve the original contour of the wound, avoid adherence to the bone, and, bit by bit, extrude automatically as granulations fill up the depths of the wound, or as the contractions of healing and cicatrization demand.

If the consistency of the tampon can be altered by changing the relative amounts of the ingredients composing it, too early extrusion can be avoided in wounds of great depth, and, conversely, rapid extrusion can be favored in shallow wounds where earlier closure is desirable and possible. With these requirements in mind, I am now using, instead of the vaselin and vaselin gauze applied in earlier cases, different mixtures of paraffin and yellow vaselin, the proportions depending on the nature of the wound. In deep wounds, paraffin and vaselin are used in a strength of ten to one; in suppurative wounds, where early closure is desired, the mixture is four parts of paraffin to one part of vaselin. The mixture is always put into the wound in a melted state, at about 110 degrees, fahrenheit, this being accomplished by immersing the jar containing the mixture in a water bath for some time before the mixture is used. It is then inserted into the wound by means of a large syringe.

I do not favor the vaselin, vaselin-gauze dressing for several reasons:

a. It is impossible to satisfactorily control the consistency of the vaselin, vaselin-gauze tampon. Due to the ingredients comprising it, this tampon cannot, at best, be uniform in its consistency.

b. Later experience has shown that, even when an excess of vaselin is added with the vaselin gauze, the gauze is still apt to become adherent to the bone at the bottom of the wound and so resist extrusion of the tampon and delay healing.

c. The wound granulations are likely to strangulate through the meshes of the gauze.

None of these complications ever arises with the paraffin and vaselin dressing, which, because of its proper degree of solidity for the particular case, the uniformity of its consistency, and its slippery surface, will always extrude much more satisfactorily than the vaselin, vaselin-gauze dressing, acting in a manner apparently somewhat similar to the bipp tampon. Furthermore, it has been found that the bacteriophage occurs spontaneously just as frequently as with the gauze dressing; also, the laboratory-bred phage, when introduced, acts as favorably. I have been unable to find any shortcomings of this dressing as compared with either the bipp or the vaselin, vaselin-gauze dressing. Bipp, however, may be contraindicated because of the possible unfavorable chemical action of the iodoform upon the bacteriophage.

Technique. The usual sequestrectomy and saucerization are completed, and a culture is taken. (If a specific phage has already been found from a culture previously taken from an existing sinus, two-thirds of a test tube of this phage is poured into and over the wound, so that the whole surface is bathed.) The wound is then packed with a paraffin and vaselin mixture, usually seventy-five per cent. paraffin to twenty-five per cent.

vaselin; or, in cases where the wound is deep and made through heavy muscles, ninety per cent. paraffin to ten per cent. vaselin. No vaselin gauze whatsoever is used. The paraffin and vaselin are heated and poured in as a liquid, or forced in by pressure through a large syringe. In most cases, the syringe is the method of choice, in order to insure penetration of the mixture to the innermost recesses of the wound.

One end of a rubber catheter is inserted through the paraffin-vaselin wound tampon to the bottom of the bone cavity. The other is allowed to project through the dressings and cast (which are applied as usual), with a sterile gauze or cotton over the end. If the laboratory examination of the culture reveals that it is possible to develop a bacteriophage specific for the organism presented, ten cubic centimeters of this phage are injected through the rubber catheter once or twice a week. Care should be taken when making periodic injections not to infect or contaminate the end of the tube. Should the bacteriophage appear spontaneously in the wound, injection of the laboratory-bred phage is still of advantage in that it accentuates the action of the native phage, and may be a more specific one. This practice is of still further advantage because, if an original phage does not completely destroy a culture, the organisms that survive give rise to a resistant strain which may be pathogenic for its host but is affected by the old bacteriophage. In large wounds, several catheters may be inserted, some of which are multifenestrated. Inasmuch as the catheter is firmly imbedded in the paraffin-vaselin tampon, the injected phage fluid cannot flow backward between the catheter and the tampon. It must, therefore, make its way *inward* between the tampon and the wound granulations, and thus, by reason of its own bulk, spread widely. Furthermore, since the phage is, by nature, a multiplying organism, it will thus automatically spread over the wound surface.

TABLE I

RESULTS OF TREATMENT*

Average Healing Time	6 months
Average Number of Cast Dressings	3
Average Number of Weekly Dressings (to complete skin healing)	3
Appearance of Bacteriophage:	
Spontaneous	94 per cent.
Introduced	6 per cent.
Type of Infecting Organism:	
Staphylococcus	40 per cent.
Streptococcus	15 per cent.
Mixed:	
Staphylococcus Predominating	38 per cent.
Streptococcus Predominating	15 per cent.
Tuberculosis	2 per cent.
Bacillus Welchii (present with other organisms)	7 per cent.
Flora Changed During Treatment (usually to a more favorable type of organism, resulting in rapid healing.)	22 per cent.

* Based on a series of 100 consecutive cases.

At the end of eight weeks the cast is removed and the wound dressed, great care being taken not to traumatize the granulating surfaces. The discharge around the edges of the wound is wiped off very gently with sterile gauze and the skin cleansed with benzin.

If the wound is not entirely healed when the cast is removed, it is again bathed with a test tube of the prepared specific phage fluid and a catheter or catheters inserted to the depths of the wound. A paraffin-vaselin tampon is used as before and a cast applied for an eight-week period. A culture is also taken at this time to determine whether the bacterial flora of the wound has changed, and also whether a more specific race of phage can be obtained. Periodic injections through the catheter are given as before.

I have recently completed a statistical study of 100 consecutive cases treated by this method which shows that the average healing time for a case of osteomyelitis so treated is about six months. Three casts are applied at intervals of eight weeks, and, after removal of the third, weekly dry dressings are done until skin healing takes place. The type of infecting organism varies,—staphylococcus, or a mixed infection with staphylococcus predominating, being the most frequent. It is interesting to note that the bacillus welchii appeared in seven of the series of 100 cases. However, the rod was extremely weak and attenuated and did not interfere in any way with the healing of the wound. The flora changed in twenty-two per cent. of the cases, usually to a more favorable type of organism, resulting in rapid healing.

Those cases in which a native phage develops usually do very well without the insertion of a laboratory-bred phage. However, in view of our latest investigations, we feel it is wise to inject periodically a race of phage of the highest potency, in order to have at work for a maximum period of time a phage of the highest specificity. In this way, any possible decrease in potency of the native phage is offset.

We have done extensive research to determine the relative effectiveness of plain and irradiated vaselin, and have established that there is no difference in their effect upon either bacterial cultures or different races of the bacteriophage. A résumé of the experiments follows:—

September 7, 1931.
September 17, 1931.
Staphylococcus broth cultures placed in contact with irradiated vaselin on petri dishes; cultured every three days for four weeks; all cultures grew in twenty-four hours.

October 19, 1931.
October 22, 1931.
Staphylococcus broth cultures placed in contact with plain vaselin on petri dishes; cultured every three days for four weeks; all cultures grew in twenty-four hours.

December 3, 1931. Four staphylococcus plates sealed with irradiated vaselin on opposite sides of petri dish (air space between culture and vaselin); cultured every week until March 3, 1932; all cultures grew in twenty-four hours.

February 27, 1932. Staphylococcus broth culture in contact with irradiated vaselin in petri dish; cultured every week until April 11, 1932; all cultures grew in twenty-four hours.

February 27, 1932. Bacillus coli broth culture in contact with irradiated vaselin in petri dish; cultured every week until April 11, 1932; all cultures grew in twenty-four hours.

February 27, 1932. Streptococcus hemolyticus broth culture in contact with irradiated vaselin in petri dish; cultured every week until April 11, 1932; all cultures grew in twenty-four hours.

February 27, 1932. Staphylococcus broth culture in contact with plain vaselin in petri dish; cultured every week until April 11, 1932; all cultures grew in twenty-four hours.

February 27, 1932. Bacillus coli broth culture in contact with plain vaselin in petri dish; cultured every week until April 11, 1932; all cultures grew in twenty-four hours.

February 27, 1932. Streptococcus hemolyticus broth culture in contact with plain vaselin in petri dish; cultured every week until April 11, 1932; all cultures grew in twenty-four hours.

September 7, 1931.
September 17, 1931.
Bacteriophage culture placed in contact with irradiated vaselin on petri dishes; tested every three days for four weeks for ability to lyse susceptible staphylococcus cultures; all bacteria completely destroyed in twenty-four hours.

October 19, 1931.
October 22, 1931.
Bacteriophage broth cultures placed in contact with plain vaselin on petri dishes; tested every three days for four weeks for ability to lyse susceptible staphylococcus cultures; all bacteria completely destroyed in twenty-four hours.

February 27, 1932. Bacteriophage broth solution put into well in large tube of irradiated vaselin; tested for ability to lyse staphylococcus culture every week until April 11, 1932; culture of staphylococcus completely destroyed in twenty-four hours.

February 27, 1932. Bacteriophage solution put into well in large tube of sterile vaselin; tested for ability to lyse staphylococcus culture every week until April 11, 1932; culture of staphylococcus completely destroyed in twenty-four hours.

April 11, 1932. Irradiated vaselin in contact with photographic film for forty-eight hours; did not fog the film.

Conclusion: No difference was noted in the effect of the irradiated and that of the plain vaselin upon the bacterial cultures and the bacteriophage.

My experience with this new method for treating osteomyelitis has convinced me that it is far superior to any other method I have used, and this conviction is borne out by the statistical study which shows the time of healing materially reduced. A summary of the advantages of the dressing follows:—

1. It is simple in its application, requiring a minimum amount of labor on the part of the surgeon and his staff.

2. It does not interfere with the immobilization of the part (as, for example, in the case of a compound infected fracture or suppurating joint), nor does it favor oedema of the granulations or the soft structures because of inequality of pressure at or in the immediate neighborhood of the wound, since there is no window in the cast. This is quite contrary to the Carrel-Dakin or maggot method of treatment, both of which must, of

necessity, have a window in the cast. I believe that a uniform pressure over the wound and neighboring tissues (such as this method affords) will avoid exuberant granulations and oedema,—an important consideration in the healing of a wound, as is exemplified in the case of varicose ulcers.

3. The paraffin-vaselin tampon automatically yields to the encroachment of granulation, healing, and closure of the wound, thus gradually extruding and keeping up a constant physiological pressure upon the surface of the wound at all times. This is more effective than frequent dressings by the surgeon, and, in addition, avoids the possibility of reinfecting the wound by a foreign flora of bacteria.

4. This dressing is favorable to the appearance of the native bacteriophage and to the periodic introduction of a laboratory-bred phage.

5. It requires a very short period of hospitalization.

In addition to its application to infected bone wounds, the bacteriophage has proved a most efficacious specific agent in combating lesions such as furuncles, boils, carbuncles, and phlegmons. For these conditions it may be applied in two ways:—

1. It may be thoroughly rubbed over the surface of the wound and the lesion covered by sterile pads soaked in bacteriophage; or, if the lesion is of extensive size or depth, it may be dressed with the paraffin and vaselin tampon with a catheter incorporated for periodic introduction of bacteriophage;

2. It may be injected subcutaneously into the soft parts by means of a hypodermic needle about the periphery of the lesion.

In bacteriemia, particularly with staphylococcus aureus, a bacteriophage prepared with asparagin as a medium and injected into the blood stream, has, in the hands of Dr. MacNeal* reduced the mortality from practically one hundred per cent. to less than fifty per cent., even when there have been two positive blood cultures. Not only is the bacteriophage a successful local therapeutic agent, but it has the added advantage of helping to establish a possible general immunity on the part of the patient. Also the bacteriophage is, to some degree, effective in experimental animals when injected at a site distant from the infected focus.

The invariable excellence of the results of this new method of treatment for infected wounds should make it unquestionably preferred by all those who experience its advantages over former methods. I believe that the bacteriophage will eventually become one of the surgeon's important weapons against infection. Its potency has become so widely recognized that certain governments (India and Brazil) have passed laws that it be kept constantly on hand for use in certain intestinal diseases. My desire is to stimulate the interest of the surgical world in a phase of bacteriology which will have a profound influence on the future treatment of surgical infections.

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THE PRODUCTION OF CHRONIC ARTHRITIS BY THE INJECTION OF WEAK ACIDS, ALKALIES, DISTILLED WATER, AND SALT SOLUTION INTO JOINTS*†

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It has been shown that arthritic-like changes can be produced by injecting a small amount of a strong chemical irritant (tincture of iodin or pure carbolic acid) into a joint (Axhausen[1], Key[2], and Burckhardt[3]). Seeliger[4] produced similar changes in the knee joints of rabbits by repeated injections of 1/50 normal HCl into the joint and believed that the acid reaction within the joint was responsible for the arthritis. Häbler[5] repeated Seeliger's experiments and obtained similar results, but he also produced similar arthritic changes in rabbits by repeated injections of distilled water into the knee joints. Häbler concluded that the arthritis was caused by cartilage damage and that the cartilage damage was caused by a change in the osmotic pressure of the fluid in the joint.

In this paper I shall present the results of a series of experiments in which chronic progressive arthritis was produced by the repeated injection of weak acids, weak alkalies, distilled water, or salt solution into the joints of experimental animals.

MATERIAL AND METHODS

Thirteen normal adult rabbits were used. The animals were anaesthetized with ether. The knees were wet with alcohol and the irritating fluids were injected directly into the knee joints, using a hypodermic syringe with a small (25 gauge) needle. The fluids used were N/50 HCl, N/50 NaOH, distilled water, 0.85 per cent. NaCl and 10 per cent. NaCl. The N/50 acid and alkali were made up in isotonic (0.85 per cent.) sodium chlorid solution. From one to two centimeters of the fluid were injected into each knee joint three times a week and from eight to twenty-eight injections were given as shown in Table I. The animals were sacrificed at intervals of from one to eighty-five days after the last injection. The knee joints were cultured, then examined in the gross, fixed in ten per cent. formalin, sectioned, and stained with hematoxylin and eosin and the sections studied.

GROSS PATHOLOGY

(1) Joints Injected with N/50 Hydrochloric Acid: There were seven joints in this series. One which received eight injections and was examined ten days after the last injection showed slight thickening of the synovial membrane and fat pads and slight hyperaemia. The second

* From the Department of Surgery, Washington University School of Medicine, St. Louis.

† Presented at the Annual Meeting of the American Orthopaedic Association, Toronto, June 16, 1932.

TABLE I

	Number of Injections	*Days*	Right Knee		Left Knee	
			Material Injected	*Arthritis*	*Material Injected*	*Arthritis*
749–50	8	10	HCl	+	NaOH	+
741–2	10	3	"	++	"	++
776–7	16	1	"	++	"	++
778–9	19	42	"	+++	"	+++
739–40	28	28	"	+++	"	+++
743–4	28	85	"	++++	"	++++
745–6	28	85	"	++++	"	+++
755–6	17	5	H_2O	++	0.85% NaCl	++
751–2	28	28	"	+++	"	++++
753–4	28	85	"	++	"	++++
759–60	28	28	"	+++	10% NaCl	+
757–8	28	42	"	+++	"	+
780–1	19	85	"	++++	"	+++

Summary of experiments reported in this paper. The + marks indicate the degree of arthritis present in each knee and the number of days indicates the period after the last injection.

received ten injections and was examined three days after the last injection. This joint contained a moderate amount of cloudy fluid and the synovial membrane was markedly thickened and hyperplastic, and was invading the cartilage all around its margins. The third received nineteen injections and was examined forty-two days after the last injection. This joint also contained a moderate amount of cloudy fluid and the synovial membrane was markedly thickened and stained yellowish-brown in color. There was some erosion of the cartilage around its margins and some softening of the cartilage covering of the bearing surfaces of the condyles and femur. The patella was broadened and its surface roughened. At several points on both the femur and the tibia there was moderate thickening of the bone at the borders of the cartilage. The fourth joint received twenty-eight injections and was examined twenty-eight days after the last injection. In this joint there was slight periarticular thickening and the synovial membrane was considerably thickened, hyperplastic, and stained a light yellowish-brown in color. There were some synovial bands and adhesions in the quadriceps pouch and posterior capsule with considerable erosion of the cartilage on the borders of the

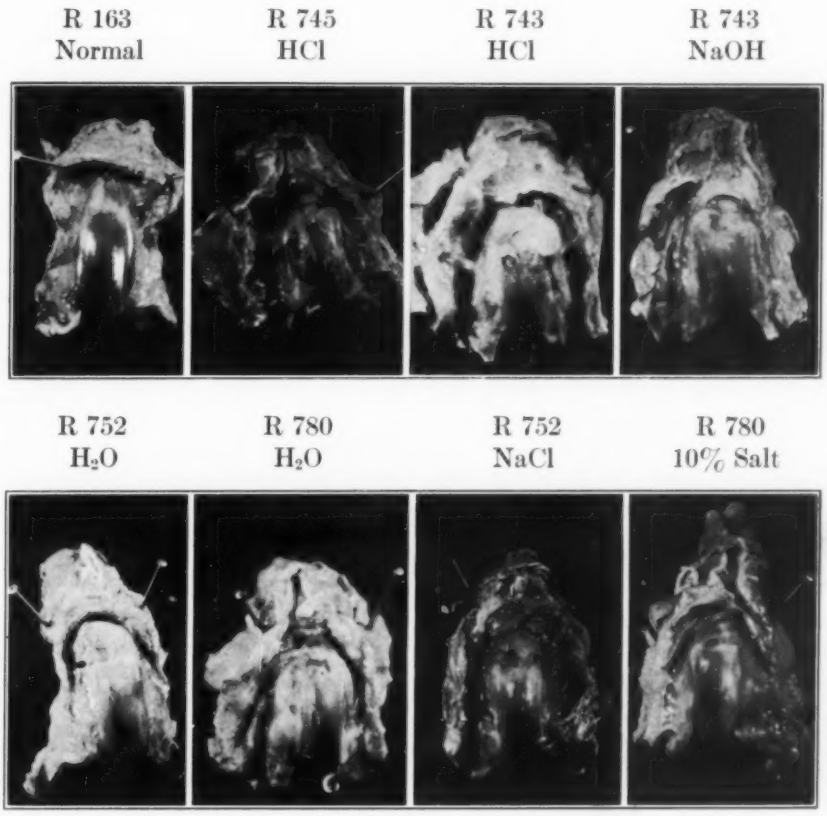

FIG. 1

Gross appearance of chronic arthritis in the knee joints of a series of rabbits induced by repeated injections of mild irritants. Upper left is a normal joint for comparison. Other figures are as marked.

condyles of the femur and on the anterior portion of the tibia. There was some marginal hypertrophy around the borders of the condyles of the tibia and femur.

The other two joints received twenty-eight injections and were examined eighty-five days after the last injection. Both joints contained a slight amount of excess clear fluid and in both the synovial tissues were moderately thickened and hyperplastic and there was softening or erosion of the bearing surfaces of the condyles. In one there was moderate overgrowth of the cartilage at the upper end of the patellar surface of the femur, especially on the internal condyle, and considerable erosion of the cartilage around the posterior borders of the condyles with hypertrophy of the margins of the condyles of the tibia. In the other there was slight marginal hypertrophy around the borders of both bones with a small ulcerated area at the upper end of the internal condylar ridge.

(2) NaOH. This series comprised the left knees of the rabbits in which the right knees received hydrochloric acid. The gross changes in

the sodium hydroxid knees were almost identical with those which had received the acid. There was the same hyperaemia in the earliest joints and the thickening of the synovial tissues and hypertrophy of the fat pads were present in those which had received ten and fifteen injections. Likewise, the hyperplastic synovial tissues exhibited a tendency to invade the margins of the cartilage. In those which had received nineteen to twenty-eight injections there was also considerable marginal hypertrophy of bone and cartilage on both the tibia and the femur, with erosion of the cartilage over the bearing surfaces of the bones, and the changes were of about the same degree as in the corresponding knees of the acid series.

(3) H_2O. There were six joints in this series. The first one received seventeen injections and in it the synovial membrane was moderately thickened and hyperaemic, while the joint contained a small amount of excess, slightly cloudy fluid. The second joint received nineteen injections. It contained a slight amount of excess fluid, the synovial membrane was moderately thickened and grayish-pink in color and there were numerous coarse bands crossing the joint cavity. There was softening and erosion of the cartilage on the bearing surfaces of the femur and tibia and a punched-out defect on the front of the femur at the upper margin of the patellar surface. There was marked proliferation of the bone and cartilage around both condyles of the femur and around the margin of the internal condyle of the tibia. The other four joints each received twenty-eight injections and were examined in twenty-eight, twenty-eight, forty-two, and eighty-five days.

One twenty-eight-day joint contained a considerable amount of excess clear fluid. The synovial membrane was moderately thickened and stained reddish-brown in color. The cartilage was softened and roughened over the bearing surfaces of the femur and tibia, and there was a small amount of proliferation of the cartilage on the anterior surface of the femur with slight thickening around the margins of the tibia. On the anterior surface of the femur above the cartilage margin there was a definite thickening of the cortical bone. In the other twenty-eight-day joint the changes were similar, except that there was a moderate amount of periarticular thickening and no thickening on the femur above the cartilage. The forty-two-day joint showed marked periarticular thickening with numerous bands in the hyperplastic synovial membrane and relatively little change in the cartilage. In the eighty-five-day joint there was a slight excess of synovial fluid, the synovial membrane was moderately thickened and stained, and there was slight roughening of the bearing surfaces of the femur and tibia with slight invasion of the cartilage, but no definite hypertrophy of the cartilage or bone.

(4) Normal Sodium Chlorid (0·85 per cent. NaCl). There were three joints in this series. The first received seventeen injections and was examined five days later. This joint exhibited moderate thickening and hyperaemia in the synovial membrane and slight hypertrophy of the

internal condylar ridge. The second received twenty-eight injections and was examined twenty-eight days after the last injection. The changes were similar to those which had occurred in the right knee of the same animal which had been injected with distilled water, but were more marked in degree. The synovial membrane was thickened and stained to a variable degree. The softening of the bearing surfaces of the patella, femur, and tibia were more marked and the marginal hypertrophy was greater while there was some definite invasion of the cartilage by the hyperplastic synovial membrane. The third joint received twenty-eight injections and was examined eighty-five days later. In it also the changes were similar to those in the corresponding joint which had been injected with distilled water, but were more marked in degree.

(5) Ten Per Cent. NaCl. There were three joints in this series. The first received twenty-eight injections and was examined twenty-eight days after the last injection. It contained a slight amount of excess fluid, showed slight hyperplasia and staining of the synovial membrane, and the changes were definitely less in degree than in the corresponding joint which had been injected with distilled water. In the second joint which received twenty-eight injections and was examined forty-two days after the last injection, the changes were similar to those in the corresponding joint which had received distilled water, but were much less in degree, and the chief departure from normal was a punched-out defect in the tissue on the front of the femur above the cartilage. This defect extended down to the bone and the base was covered by a very thin, firm, connective-tissue membrane. The third joint received nineteen injections and was examined at the end of eighty-five days. This knee showed no excess fluid. The synovial cavity contained numerous bands and a few small villi and the synovial membrane was rather firm and fibrous in appearance. The fat pad was shrunken and fibrous in character. The tissues above the cartilage on the front of the femur were thin and smooth and atrophic in appearance. There was slight hypertrophy of the upper end of the ridge on the external condyle and a large dome-like exostosis was present on the side of the femur near the lower end of the condyle.

In general the changes in these joints consisted of hyperaemia followed by hyperplasia with formation of synovial bands and villi. The hyperplastic synovial membrane tended to invade the cartilage, and hypertrophy of bone and cartilage occurred around the margins of the cartilage. In all of the joints there was a definite tendency to softening and erosion of the cartilage over the bearing surfaces of the bones. For the most part the semilunar cartilages remained normal, but in a few instances they were roughened. After acid, alkali, or distilled water, the changes were approximately of the same degree in the various joints. After the injection of normal salt solution, the changes were slightly more marked than in the above and in the joints which had received ten per cent. salt solution, the changes were less marked and there was a definite tendency to fibrosis in the synovial membrane.

MICROSCOPIC CHANGES

HCl. *Synovial Membrane:* The joint which had received sixteen injections of hydrochloric acid, and was examined on the day after the last injection, showed marked thickening of the synovial membrane and infiltration of the synovial tissues with large numbers of leucocytes and small and medium-sized round cells. In the joint examined ten days after the last injection, the leucocytes had disappeared and the infiltration with round cells had increased to a considerable extent. In the early joints the synovial cells were enlarged and increased in number and there was considerable fibroblastic reaction in the sub-synovial tissues with a small amount of villus formation. In the later joints of this series the synovial thickening and infiltration were still present, but were less in degree. In the forty-two-day joints there was a moderate amount of hyaline-like degeneration and many of the cells were vacuolated while the small round cells were arranged in nodules which were often perivascular. In the eighty-five-day joints there was moderate villus formation, but the synovial membrane reaction was considerably decreased, although there still remained a moderate amount of round-cell infiltration in the areolar subsynovial tissues and some small giant cells were present, while in other areas there appeared to be some fibrosis of the surface.

Cartilage and Bone: In the joints which had received eight injections, the cartilage surface was intact, but the cells near the surface stained poorly and appeared to be dead, and there were a few empty lacunae in this area. In the joints which had received nineteen injections and were examined forty-two days after the last injection the surface zone of the cartilage was dead, the bearing surface was degenerated and in some places was broken and clefts extended down into the basal zone. In the middle zone the cells for the most part were living and in the basal zone there were many dead cells, some of which were degenerating and forming cysts. Evidence of regeneration in the form of cell nests was present in the middle zone.

In the joint which had received twenty-eight injections and was examined twenty-four days later, most of the cartilage was dead and over the bearing surfaces of the femur it was disintegrating and beginning to separate from the underlying bone. There was no normal structure left, but in the apparently dead matrix in the central areas there were numerous cell nests, some of which were quite large in size, while the marginal areas of the cartilage appeared to be unusually cellular. In some places the subchondral bone appeared to be fragmented and necrotic, and there was definite new bone formation in the subchondral regions and at the lateral borders of the tibia and femur. The fibrous cartilage showed no necrosis.

In the two joints which received twenty-eight injections and were examined eighty-five days later, the bearing surfaces of the joint were completely devoid of cartilage and the exposed bone was necrotic and

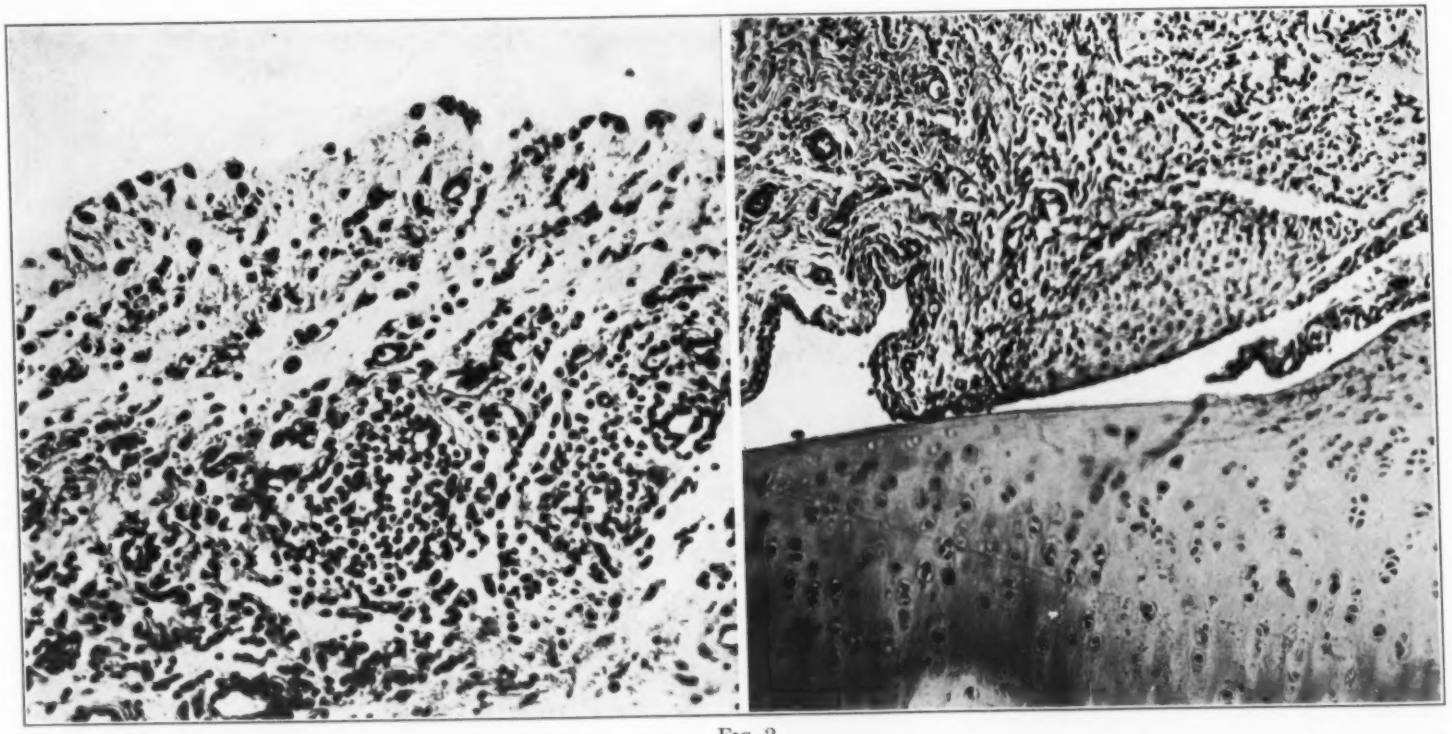

FIG. 2

Left: R 778–9: Synovial membrane from chronic arthritis produced by repeated injections of N/50 HCl into the knee joint. Note the mild synovial hyperplasia and subsynovial infiltration with nodules of small round cells.
Right: R 739–40 (HCl) showing hyperplastic synovial tissue overhanging the margin of the cartilage.

eburnated, while the blood vessels near the surface of this bone were thrombosed. In other areas the remaining cartilage was dead and fibrillated and there was some invasion of the underlying bone by cartilage and osteoid tissue. The patellar surface of the femur was covered by a thin layer of necrotic cartilage from which the cells had almost entirely disappeared. A few cell nests were present in the apparently necrotic matrix. There was definite osteophyte formation at the cartilage margins.

NaOH: In the joints which received repeated injections of NaOH, the changes in the synovial membrane were practically identical with those present in the joints which had received acid, except that in the early joints many of the synovial cells were shrunken rather than swollen. As in the acid joints this acute damage to the surface was followed by a stage of synovial hyperplasia and villus formation with infiltration of the subsynovial tissues with small and medium-sized round cells. In the alkali joints macrophages engorged with pigment were seen more frequently than in the acid joints and there seemed to be a slightly greater tendency to fibrosis of the subsynovial tissues. Also the fibrous areas of the synovial surface which were very little affected in the acid joints showed some surface necrosis and degeneration in the alkali joints.

The cartilage in the alkali joints was damaged in the same way as in the acid joints, except that the death of the cells near the surface occurred earlier and was slightly greater in extent. This surface necrosis was accompanied by evidence of hyperplasia in the form of cell nests in the deeper layers and in the joints which had received more injections there was marked degeneration, fibrillation, and erosion of the cartilage, with exposure and eburnation of the underlying bone, and some new bone formation at the margins of the condyles and on the sides of the femur. In some places the cartilage had separated from the calcified zone. As in the acid joints, occasional small cysts were present in the cartilage.

H_2O: In the joints which received water the changes in the synovial membrane were practically identical with those which had received acid. The cartilage in these joints was fibrillated and eroded and the underlying bone was exposed and eburnated, as in the acid joints, but the changes were more extensive. Likewise, there was somewhat more reaction on the part of the bone in the form of marginal and subperiosteal new bone formation.

NaCl (0.85 per cent.): In the joints which received normal salt solution the changes in the synovial membrane were practically identical with those in the joints which had received acid. In three of the sections small nodules of hyaline cartilage were found in the hyperplastic subsynovial tissue. The changes in the cartilage were similar to those which occurred in the joints which received acid, except that the zone of surface necrosis was not quite as deep. In some areas in the joints which received twenty-eight injections, the surface appeared to be living, while the deeper portion of the cartilage was dead, and in still other areas there was a narrow necrotic surface zone supported by a layer containing nests of living cells, and

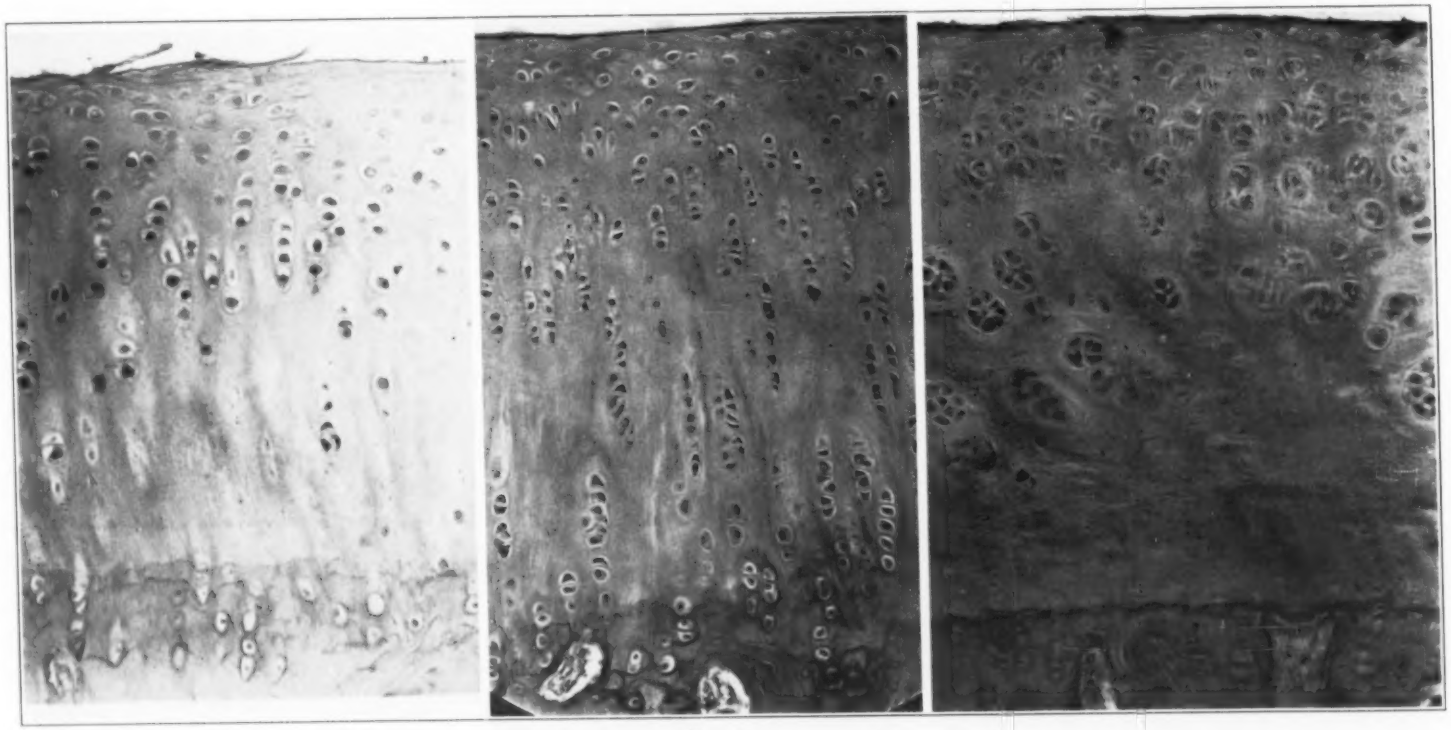

FIG. 3

Left: Cartilage from R 757–8 (H_2O) showing necrosis and disappearance of cells in the deeper layers with fairly normal surface zone.
Middle: Same joint as preceding, showing moderate regeneration in the form of cell columns in the deeper zone.
Right: R 751–2 (0.85% NaCl) showing necrosis and disappearance of cells in the depths of the cartilage with regeneration in the form of cell nests.

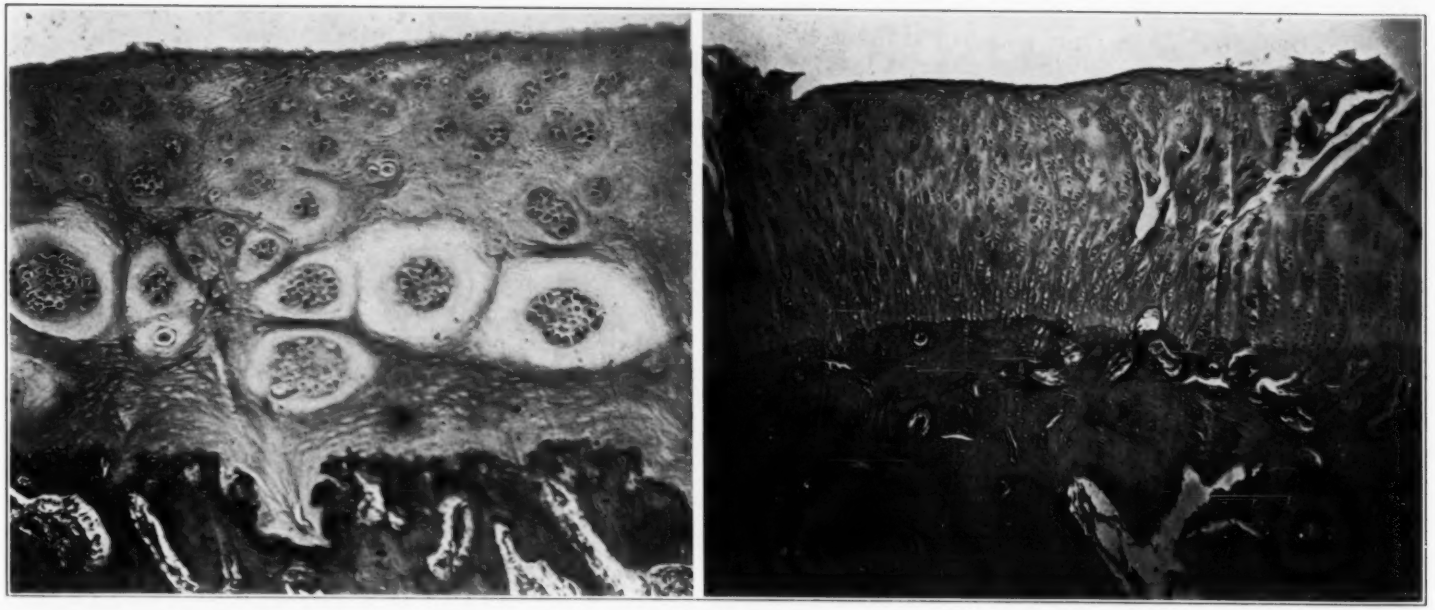

FIG. 4

Left: R 743–4 (HCl). Death of cells, especially in the deeper portions, with marked regeneration with the formation of large cell nests and surrounding zone of new matrix in the apparently dead cartilage.
Right: R 780–1 (H_2O). Localized areas of necrosis and cleft formation separated by a zone of almost normal cartilage.

beneath these there was necrosis of the deeper layers and the cartilage was beginning to separate from the underlying bone. On the whole these joints showed changes similar to those which had received acid and were of about the same degree.

In the joints which received injections of ten per cent. NaCl, there was in the early joints moderate synovial hypertrophy and hyperplasia in some areas and in the later joints there was rather marked fibrosis and some giant-cell formation. The cartilage showed surface necrosis with erosion over the bearing surfaces and fragmentation of the cartilage, but these changes were considerably less in degree than were those present in the joints which received acid or alkali or water or normal salt solution.

SUMMARY

Postmortem cultures of the joints yielded no growth; consequently, it may be assumed that the pathological changes which occurred in the injected joints were caused by the injected material. These changes can be summarized as follows:

1. *Synovial Exudate:* The acute joints (one and three days) contained a moderate excess of cloudy, straw-colored fluid and this fluid contained large numbers of leucocytes and macrophages. The subacute joints (five and ten days) also contained a moderate excess of cloudy, straw-colored fluid, but the leucocytes had largely disappeared and most of the cells were macrophages. In the chronic joints (twenty-eight to eighty-five days) the excess fluid was decreased in amount, relatively clear, and contained only a moderate number of cells (mostly macrophages).

2. *Synovial Tissues:* In the acute joints the areolar and adipose areas of the synovial surface exhibited a rather acute inflammatory reaction with hypertrophy and hyperplasia of the fixed tissue cells and infiltration of the tissues with leucocytes and small and medium-sized round cells. In the subacute joints the leucocytes had largely disappeared, but the round-cell infiltration of the loose subsynovial tissues was more marked and the hyperplastic synovial tissues tended to invade and overlap the margins of the articular cartilage. In the chronic joints the fixed tissue cells were about normal in size, but the synovial tissues were moderately thickened and infiltrated with small and medium sized round cells (Fig. 2).

The fibrous areas of the synovial surface (including the fibrocartilage) showed relatively slight changes in any of the joints.

3. *Articular Cartilage:* A variable number of the cartilage cells were killed and the death of the cells was followed by fibrillation, cleavage, and disintegration of the matrix, and occasionally by separation of the superficial cartilage from the deep calcified zone. Where only a portion of the cells in a given area were killed, the small superficial cells tended to survive, while the larger cells in the deeper zones died (Fig. 3). When some of the deeper cells remained alive, they tended to proliferate and form cell columns and cell nests and the larger cell nests were surrounded

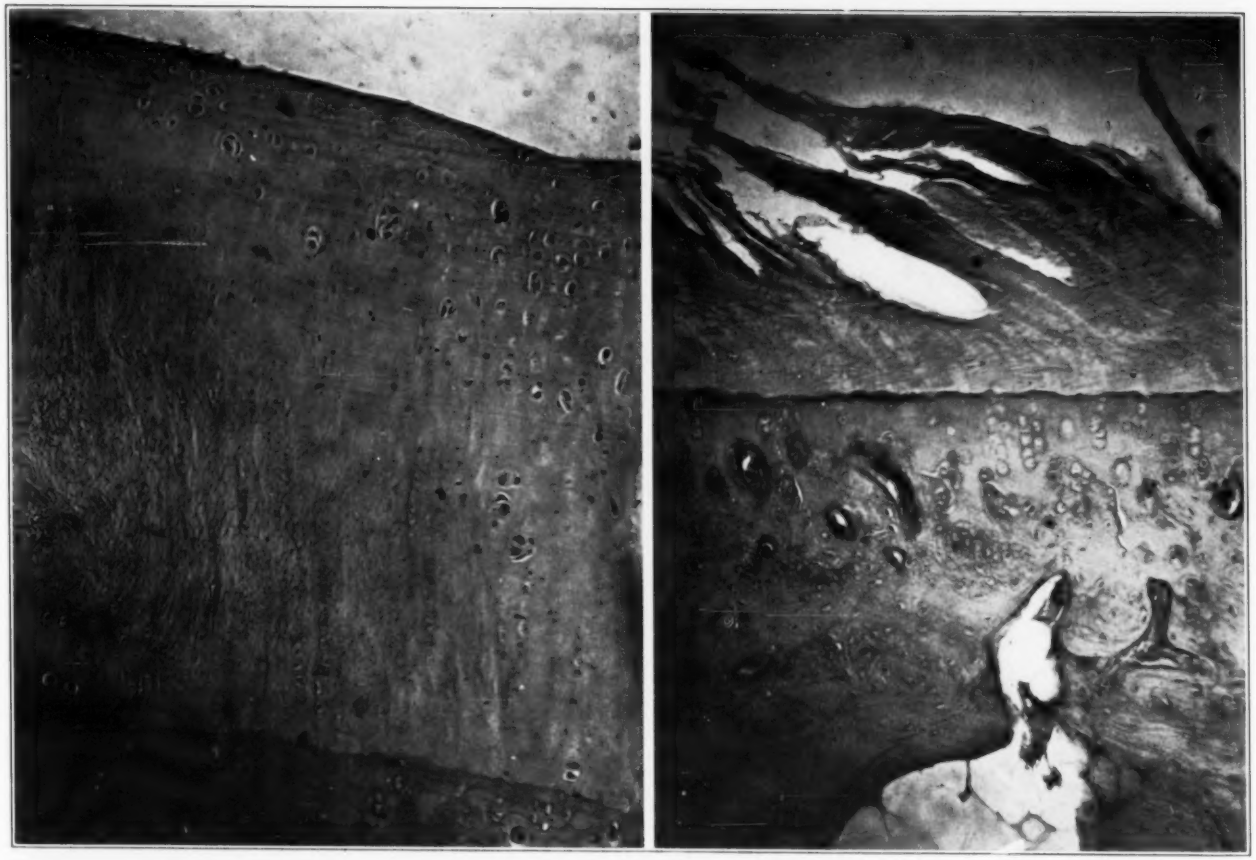

FIG. 5

FIG. 5

Left: R 753-4 (0.85% NaCl). Extensive death of cartilage cells with very little regeneration and beginning disintegration of the matrix in the deeper layers.

Right: R 745-6 (HCl). Complete death of cartilage cells with disintegration and fibrillation of the surface zone.

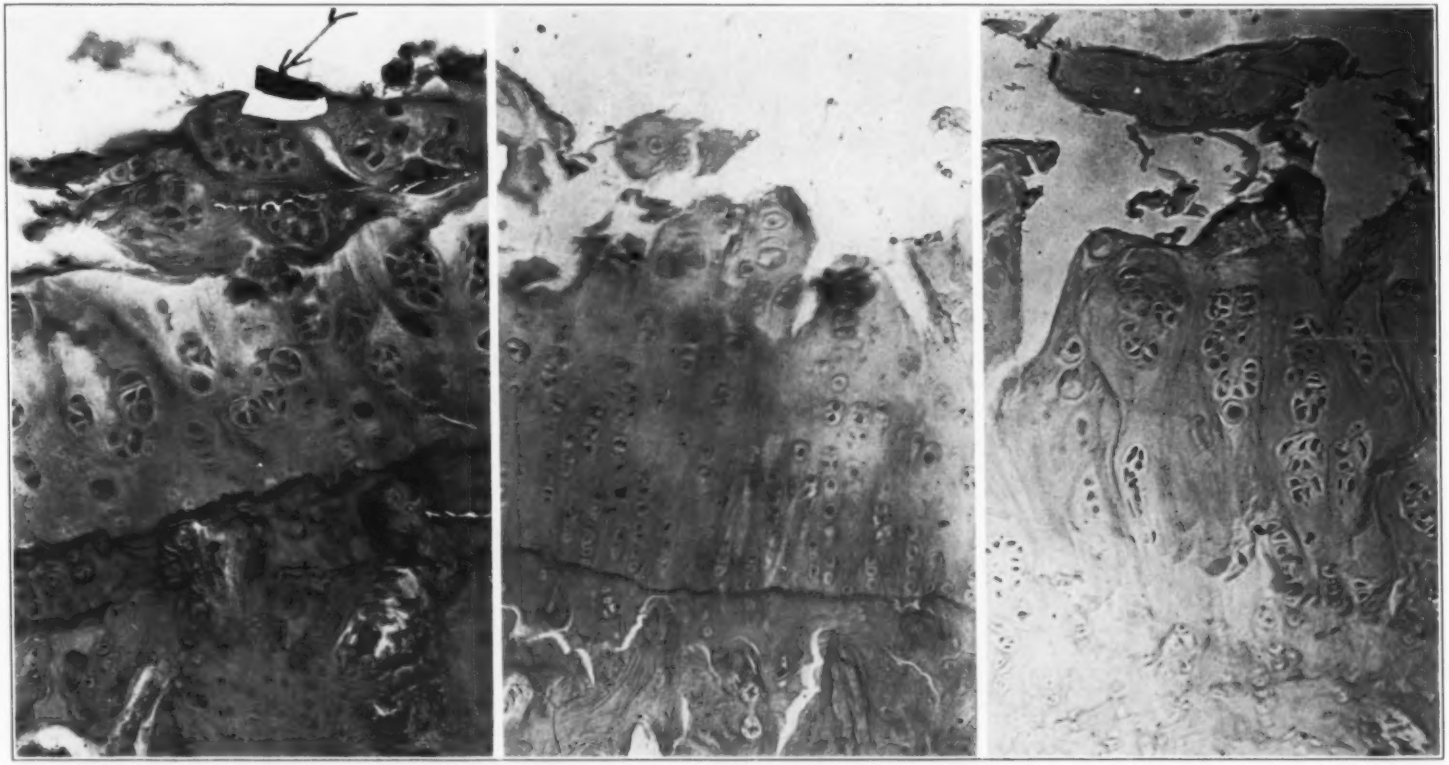

FIG. 6

Left: R 751–2 (0.85% NaCl) showing disintegration of surface with moderate regeneration and nest formation. (Arrow points to defect in the photographic film).
Middle: R 757–8 (10% NaCl). Similar to preceding, but very little evidence of regeneration.
Right: R 780–1 (H_2O). Similar to preceding with rather well marked regeneration and cell-nest formation.

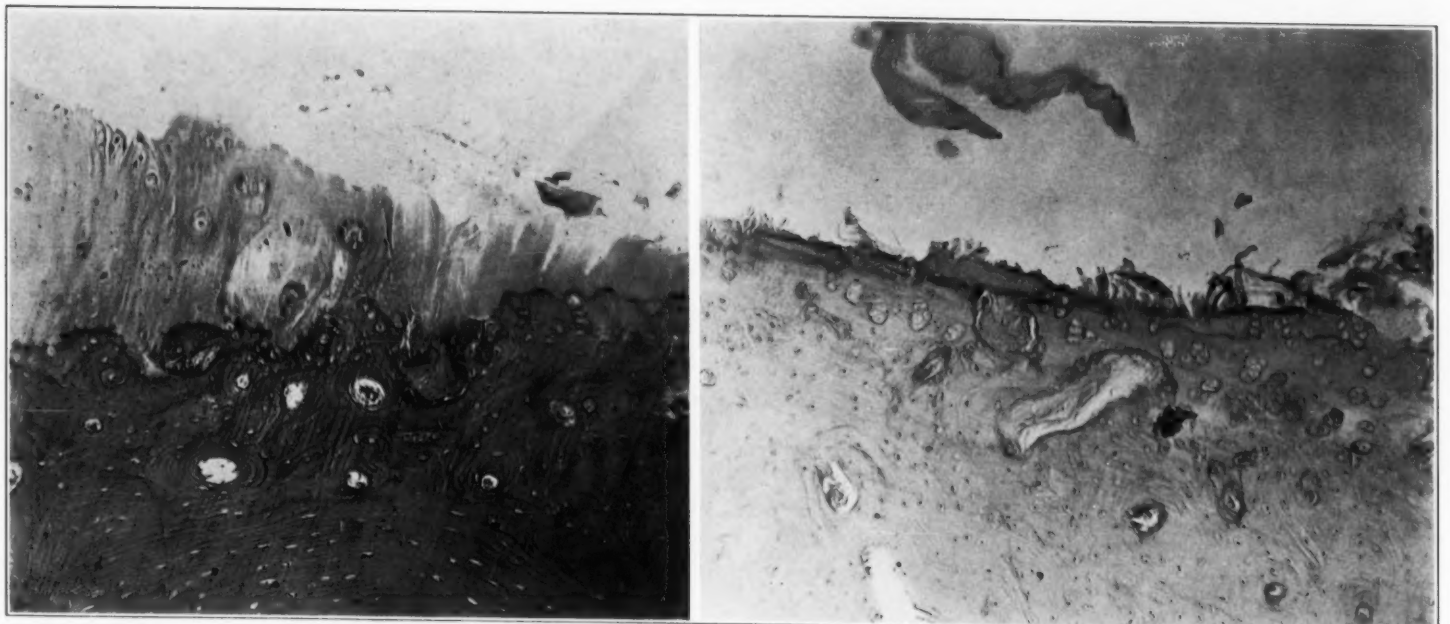

FIG. 7

Left: R 743–4 (HCl). Cell death, necrosis, and fibrillation of cartilage with erosion of surface zone. A few cell nests are present.
Right: R 745–6 (HCl). Cartilage dead, almost completely eroded and underlying bone eburnated.

by zones of newly formed hyaline matrix (Figs. 3, 4, and 6). The small cells near the articular surface exhibited relatively little tendency to proliferate.

Occasionally the cartilage necrosis was sharply localized (Fig. 4, Right), but as a rule it was diffuse and was especially marked over the bearing surfaces of the joint. Here the surface tended to disintegrate and the cartilage was in many instances eroded and the subchondral bone was exposed (Figs. 6 and 7). In joints with considerable cartilage necrosis there was a variable amount of marginal proliferation of the articular cartilage.

4. *Bone:* When the articular cartilage was eroded the underlying bone became eburnated and the bone cells near the exposed surface died. Necrosis and erosion of the cartilage over the bearing surface of the joint were usually accompanied by proliferation of cartilage and bone around the margins of the cartilage (marginal osteophytes) and beneath the adjacent periosteum (exostoses) (Fig. 9). The combination of central necrosis and marginal proliferation caused deformities of the joint. These joints did not tend to ankylose by fibrous tissue or bone.

DISCUSSION

The pathological changes just described resemble those which occur in hypertrophic arthritis in human beings and which I have produced in the knees of rabbits by resecting a rectangle of cartilage from the patellar surface of the femur.[6] Likewise, the changes in the synovial exudate and tissues resemble those produced by the repeated injection of blood or by a single injection of India ink into a joint.[7]

In the experiments reported in this paper the arthritis was caused by the repeated injection of substances which were so innocuous that a single injection would cause no permanent changes in the joint. That neither the acid reaction (Seeliger) nor the hypotonic medium (Häbler) was specifically responsible for the arthritis is evident from the observations that practically identical changes were produced by acid and alkali in an isotonic medium and even by isotonic sodium chlorid solution.

From these experiments it is evident that the articular cartilage is the most vulnerable of the joint tissues. It is readily penetrated by fluids in the joint cavity and the cells (especially the deeper cells) are easily killed by chemicals, but apparently they have lost the power of proliferation. These two observations lend support to the theory that cartilage grows from beneath rather than from the surface and that the deeper cells are younger than those nearer the surface.

The repeated injections caused inflammation of the synovial tissues and death of the articular cartilage. When the irritation is removed, the synovial tissues tend to return to normal, but the damage to the cartilage is more or less permanent. As I have pointed out elsewhere [6], when articular cartilage is killed, it is difficult for repair to take place because the cells cannot migrate through the dense matrix and the dead cartilage

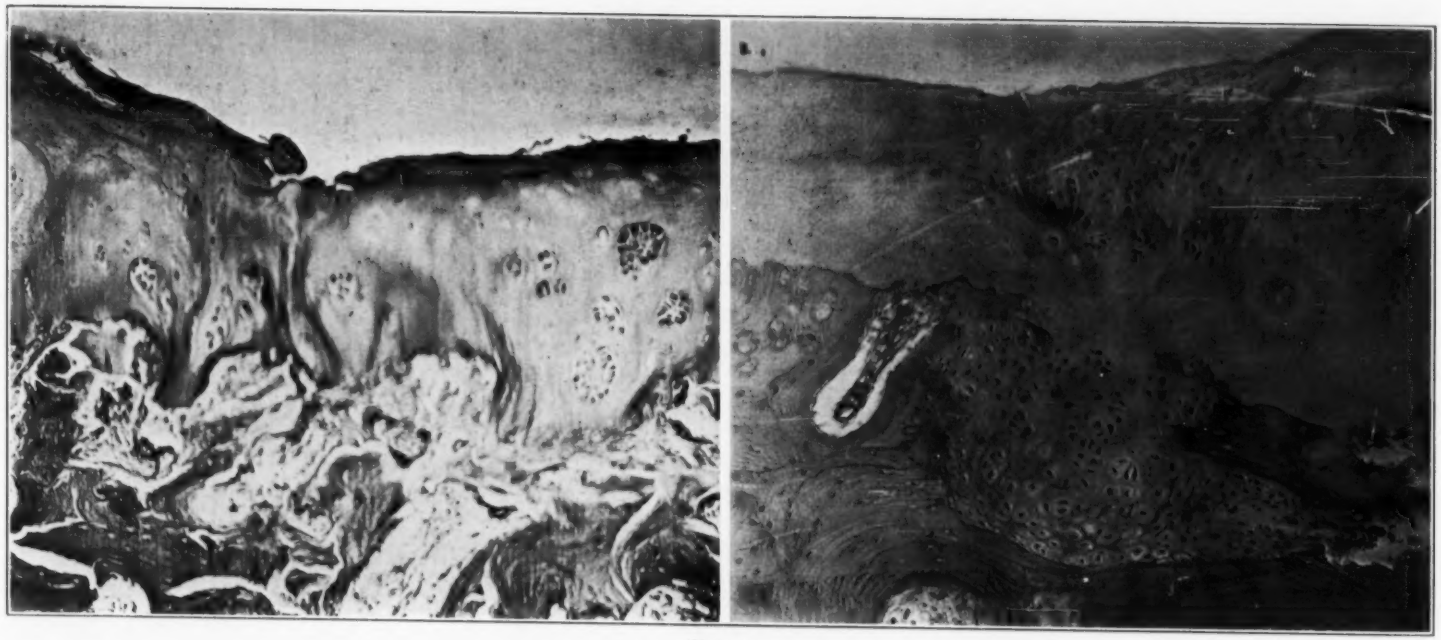

FIG. 8

Left: R 739–40 (HCl). Necrosis of cartilage and the underlying bone with beginning separation of cartilage in the form of cell nests.
Right: R 745–6 (HCl). Almost complete necrosis of cartilage with regeneration in the form of invasion of the underyling bone by the cartilage.

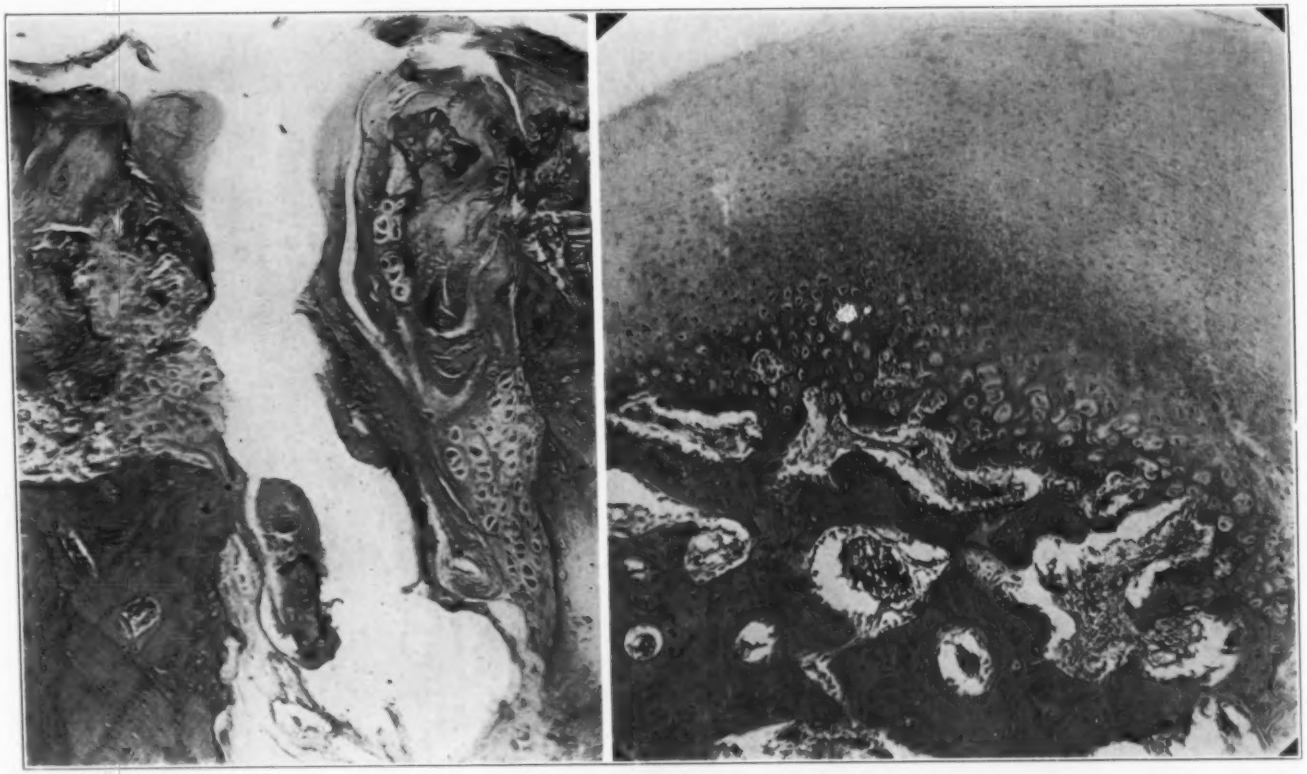

FIG. 9

Left: R 743–4 (HCl). Complete disappearance of surface cartilage with defect in the bone which is partly lined by hyaline cartilage.

Right: Same as preceding. Low-power view of a marginal osteophyte, showing fibrous surface layer which merges into cartilage and this in turn merges into bone.

remains *in situ* and prevents repair by growth from the adjacent living tissue. Not only is this true, but, when the cartilage is injured so that a raw surface is exposed, the cells adjacent to this surface die. Furthermore, when the cells of cartilage are killed, the surrounding matrix tends to disintegrate. Consequently, the effect of repeated minor injuries to cartilage is cumulative.

It is thus evident that in these experiments the arthritis followed necrosis of the cartilage and one could interpret the results as corroborating Axhausen's theory that chronic arthritis is caused by the presence of dead cartilage in the joint. However, as I have shown elsewhere, simple removal of a portion of the articular cartilage results in exactly the same type of arthritis, and the presence of dead cartilage is not necessary.[6]

Consequently, I believe that the arthritic changes reported in this paper were caused by injury to the articular cartilage. Since I have produced almost identical pathological changes in joints by the injection of bacteria (diphtheroids and cocci of low virulence) [8] (Fig. 1), and by various types of mechanical injury, it seems reasonable to assume that chronic arthritis represents the response of a joint to injury. If the injury is largely limited to the articular cartilage and the joint continues to function, the result is hypertrophic arthritis, regardless of the type of injury. If the injury is due to an acute infection, the result is a pyogenic arthritis and the ultimate result depends upon the amount of destruction which occurs before the process is arrested. If the injury is a chronic irritation, chiefly affecting the synovial tissues, the result is an atrophic arthritis.

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MAGGOTS IN TREATMENT OF OSTEOMYELITIS

A Simple Inexpensive Method

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The use of maggots in the treatment of osteomyelitis has been widely popularized by the work of the late Dr. William S. Baer[1] and by the wave of publicity which followed his investigation. Those reporting the use of maggots have found the treatment very satisfactory, and their results compare favorably with those obtained by other well known procedures. If the use of maggots for this purpose is as beneficial as the reports indicate, a further investigation of technique may be valuable.

In reviewing the literature to date, one is dismayed by the difficulties, the expense, and the time involved in the methods described. At present it is impossible for a small hospital to provide its own supply of sterile maggots, as the expense for necessary equipment as described by Baer would run into hundreds of dollars, and the culture and handling of flies and maggots would necessitate the employment of a trained, full-time technician. Sterile maggots may be purchased at a quoted rate of five dollars per thousand. This number is sufficient for one ordinary application. The number of applications necessary varies in Baer's series from one to thirty-six, with an average of eleven; at a cost of five dollars per application, the cost of maggots alone would average fifty-five dollars per patient. This cost is an important item when added to the expense of the usual prolonged hospitalization of patients with osteomyelitis. Therefore, a simple, inexpensive method, by which maggot treatment may be made available to anyone, has been worked out and will be described.

When Baer began his work, he used unsterilized maggots successfully until two of his cases developed tetanus. He then devised his elaborate and costly method of producing sterile maggots. Nevertheless, a prophylactic injection of tetanus antitoxin for all patients being treated is still advised, as a precautionary measure, by the firm selling sterile maggots. Unsterile maggots are just as efficient as sterile maggots in their action on the lesion and, had Baer given prophylactic antitoxin, his two cases of tetanus would not have occurred. The only pathogenic organism present other than tetanus was the gas bacillus. Baer proved by controlled experiments on guinea pigs that maggots protect animals from gas-bacillus infection. No cases of gas gangrene have been reported, whether sterile or unsterile maggots were used. There is, then, no valid reason why sterile maggots are more effective or safer than unsterile maggots. Livingston[2] has used unsterile maggots extensively at the Hines Memorial Hospital and there have been no unfavorable results in a large series of cases recently reported by him. Weil and Nettrour[3,7], Rohm[3], Goldstein[4], Wilson,

Doan, and Miller [5], Thorek [6], Henry [7], and Sweadner [7] have also used both sterile and unsterile maggots; and their results have not been noticeably different from those reported by Baer.

Contrary to described methods, the culture of flies and raising of maggots is amazingly simple. Under almost any conditions flies will live, lay eggs, and grow maggots if sufficient suitable food is supplied. The ease with which they can be grown may be suspected if the adverse conditions under which flies and maggots live and propagate in nature are considered. The varied conditions under which they may be grown make their controlled culture inexpensive.

In October, 1931, a supply of maggots was offered for use, in the treatment of osteomyelitis, on the service of Dr. Frank D. Dickson and Dr. Rex L. Diveley at St. Luke's Hospital. These maggots were raised on raw beef without any attempt at sterility. They were washed in a 1–1000 solution of bichlorid of mercury with twenty-five per cent. alcohol before introduction into the wound. Treatment of two cases of osteomyelitis of the hip was undertaken. Very little was known about keeping the maggots in the wounds and many escaped. Some of these were used as a stock supply and at present all our cases are treated with maggots descended from this stock.

There were no funds available for equipment,—such as incubators, cages, heating elements, thermostats, water-vapor controls, fans, etc., usually described as indispensable. A box of approximately eighteen by twenty-four by thirty inches was set on legs. Glass windows were fitted to the front. Two old thermostats from bacteriological incubators were reconditioned and installed, one being used as a safety unit. A 200-watt light was placed near the back of the box to supply heat. A pan of water

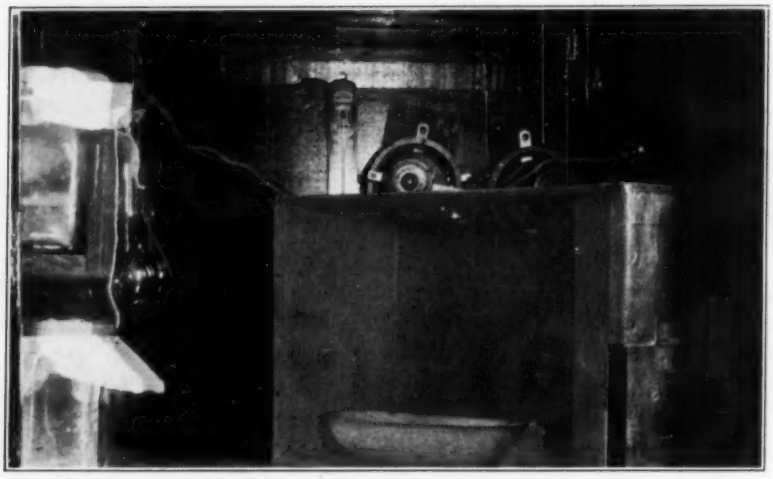

FIG. 1

Incubator showing thermostats, light to supply heat, pan for water, and shelf to shade maggots from the light.

was placed under it to provide moisture. No attempt was made to circulate the air. A small shelf was built in to hold the jars of maggots so they might be kept in the dark (Fig. 1). Any similar apparatus would be equally satisfactory. The temperature should be regulated from seventy to ninety degrees fahrenheit; the higher temperature promotes rapid growth of maggots but the flies live longer at the lower temperature.

The original stock of maggots was put on a piece of raw beef in a jar and in a few days reached adult size. Sand was poured on them and they crawled into it and formed pupae. These pupae were placed in a petri dish in a cage constructed as follows (Fig. 2): A flat box of a size that would easily fit in the incubator was secured. The top and bottom were replaced with screen wire and a small door placed in one end. The cage thus stands upright on one side of the box. The door should be at the bottom, as this prevents escape of flies when changing food and cleaning the cages. After about seven days, the pupae hatched to flies.

Flies are fed on a mixture of one ounce of honey, one dram of yeast powder, and eight ounces of water. This food is all the flies require. It should not be allowed to ferment and should be constantly present. The food was placed successively on cotton, sponge rubber, cloth, crackers, and in jars with wicks, but was found to require less attention when merely placed on a slice of bread in a petri dish. One such supply easily lasts forty-eight hours. About seven days after hatching, the flies are ready to lay and the eggs are most readily collected on a small bit of raw beef, measuring about one-half by one by one inches, which is placed in the cage on a bit of waxed paper. The eggs will hatch in eight hours or less at incubator temperature and must be removed before hatching if they are to be transferred to other media for growth. Meat should be placed in the cage for a few hours about every second day, for the purpose of collecting eggs. Meat, as a possible source of pathogenic organisms, may be entirely eliminated. The flies will lay on almost anything after about seventy-two hours. A small piece of agar will suffice, or the eggs may even be collected from the bread on which the food is placed.

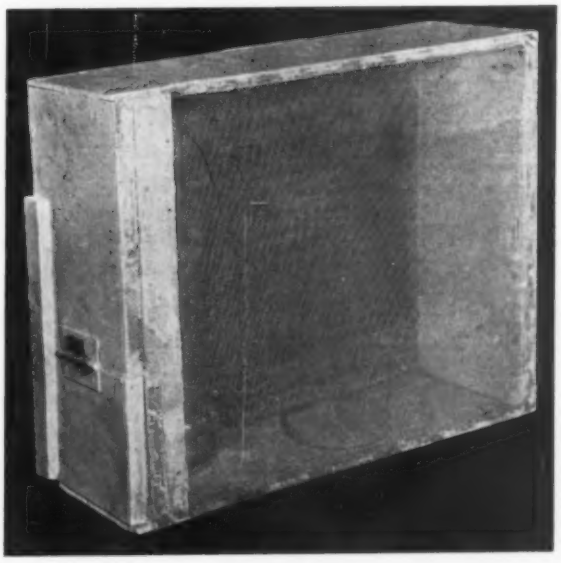

FIG. 2
Fly cage with a supply of food in place.

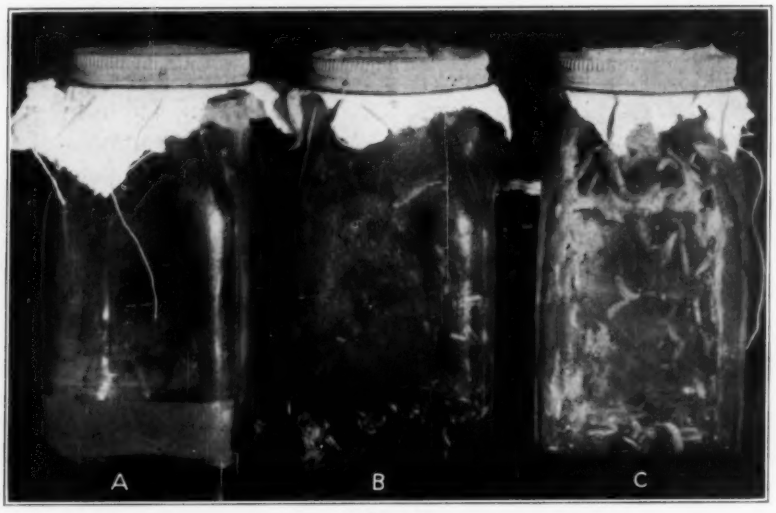

FIG. 3

A. Fresh jar of media.
B. Jar of media containing maggots forty-eight hours old.
C. Maggots washed and ready for use or storing.

The media for culturing the maggots to proper size for use in treatment is prepared as follows: A circular hole is cut in the lid of an ordinary petrolagar jar. This hole should occupy almost the entire top. A piece of raw liver, about one inch in diameter, is put in and the jar filled to the level of the top of the liver with peptone agar to which yeast has been added in the proportion of about one cake to 1000 cubic centimeters. A single layer of old sheeting is placed over the top of the jar and the lid screwed in place over it. The jars are then autoclaved twice, with a twenty-four hour interval of incubation, and stored in an icebox until needed (Fig. 3-*A*). This is one of the media used by Baer. It is the only one needed and is very satisfactory.

Eggs are transplanted to this media. This is best done with a toothpick or small scalpel kept for the purpose. Each fly will lay over 100 eggs at a time and about four to six such layings can be raised to the size required in a jar of media made as above. The jars are then incubated until the maggots are the proper size for use. The rate of growth depends on temperature and relative food supply, and usually forty-eight to seventy-two hours are necessary. At this time the maggots will be about one-fourth inch long or slightly more (Fig. 3-*B*). During this growth period, care must be taken to keep the cloth cover dry so that it will admit air. If it becomes wet, due to maggots crawling over it, the air is shut off, and the maggots die in as short a time as six to eight hours.

When the maggots have grown to the proper size, the jars may be placed directly in the icebox until needed; but it is much more convenient and time-saving if several jars of maggots are grown to the proper size at the same time and washed up ready for use before storing. The washed

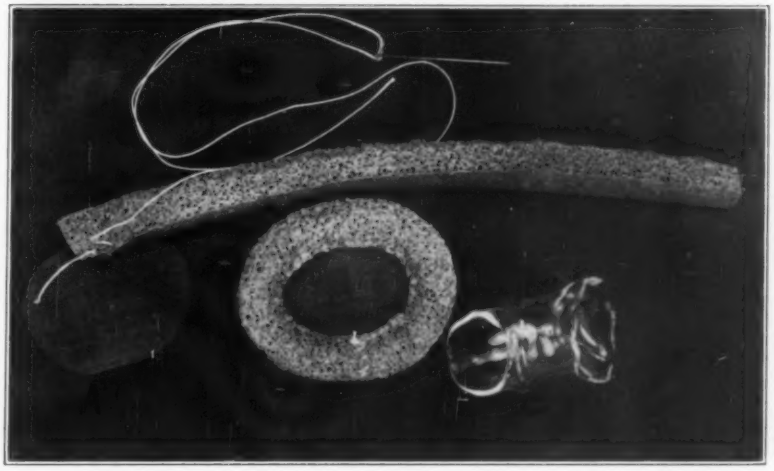

FIG. 4

A. Method of edging screen with sponge rubber.
B. Completed screen.
C. Glass tube to be used in wound to allow drainage and prevent too early closing of the skin edges.

maggots will remain in good condition for a longer time than the unwashed ones. At first, considerable difficulty was found in separating the maggots from the media on which they were grown. However, it was noted that about twenty-five per cent. of them float in water and about forty per cent. float in normal saline. It was then only a step to the addition of about two tablespoonfuls of sugar to each jar after it had been nearly filled with water. When the proper amount of this is stirred into the solution, the maggots all float and leave the media in the bottom of the jar; but, if too much sugar is stirred in, particles of media also float. The maggots are then dipped into an ordinary tea strainer and are thoroughly rinsed with tap water and placed for thirty minutes in a 1–1000 solution of bichlorid of mercury with twenty-five per cent. of alcohol. They are then strained again and are ready for use. Placed in an empty media jar, they may be kept in good condition in an icebox for as long as two weeks (Fig. 3-*C*). When needed, these maggots may be removed, rinsed with ice water, and implanted in the wound. When cold, the maggots are almost inactive and much easier to handle.

Each generation of flies will live and produce eggs for about four to six weeks. For replacing the flies, one laying of eggs may be grown to maturity, on a large piece of steak, in about seven days. If the usual media is used, three jars of it will be necessary to grow one "laying" of eggs to adult maggots. Large jars of media may be prepared for this purpose. When adult in size (about one-half to five-eighths of an inch long), the maggots are transferred to dry sand and will pupate in about forty-eight hours. Maggots will also pupate in a wad of dry gauze. Pupae may be kept on ice, with only a small percentage of loss, from two to three

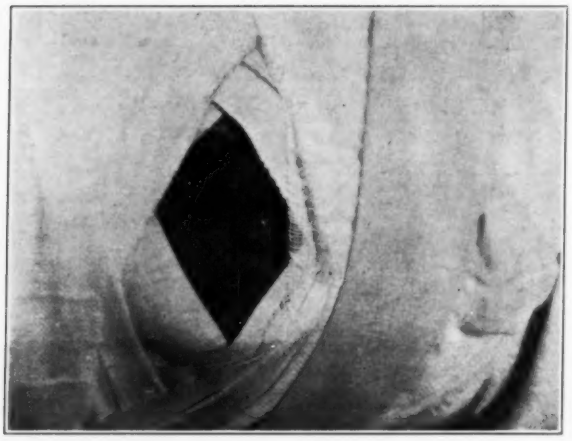

FIG. 5

Complete dressing on an extremity, showing screen held in place by adhesive and bandage.

weeks, possibly longer, before being placed in the incubator for hatching.

TECHNIQUE OF IMPLANTING MAGGOTS

In implanting the maggots and keeping them in the wound, there are several procedures which have been found useful. It is not necessary to the success of the treatment that all the maggots be kept in the wound, and one worker who has used them in a large number of institutional cases makes no effort to keep them in. However, it is very imperative, in private practice, that the patient be kept comfortable or he will not submit to the treatment. If the maggots are strictly confined to the wound, the patient has no discomfort unless there are nerves exposed. If this is the case, the pain can be controlled with sedatives and will usually disappear after the second application. I find bromid and codein the most useful drugs.

The most important single consideration in keeping the maggots in the wound is the maintenance of adequate drainage in some way, so that the maggots can not escape by the same route. It is obvious that those maggots which escape the confines of the wound are useless therapeutically, and they cause constant annoyance to the patient. The only method which I have found satisfactory for keeping the maggots in the wound consists of placing a close-fitting, screened cage over the wound and taping it down tightly. This is not always effective but, with a little experience in application, the device will become about ninety-five per cent. efficient.

The screened cage is made by cutting a piece of 60-mesh milk-strainer wire (cost forty cents per square foot) to a size about one-fourth of an inch larger than the edge of the wound (Fig. 4-*A*). This may be done from a pattern, but a little experience will enable one to cut them without. A strip of sponge rubber of soft texture and about one-half inch thick is cut. This should be about one-half inch wide and a little longer than the circumference of the screen. It is folded over the edge of the screen and sewed in place with a close stitch drawn tightly (Fig. 4-*B*). Satisfactory screens may also be made by sewing edges of the milk-strainer wire between two strips of sponge rubber or inlaying it in a window in a flat piece

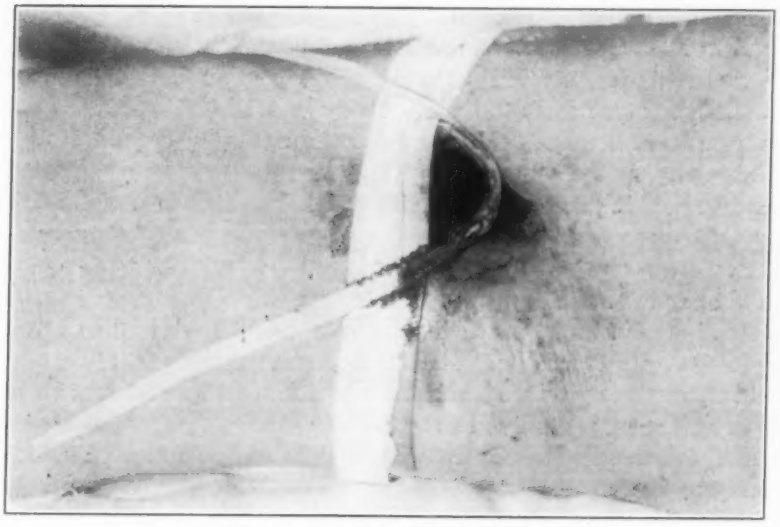

FIG. 6

Glass tube to maintain surface opening of wound, held in place by adhesive.

of sponge rubber and sewing it in place. These screens may be sterilized by boiling, but should be dry at the time of application.

The screens are applied in much the same manner as described by Child and Roberts [8]. The surrounding skin is cleaned with ether and a layer of flamed adhesive is applied to the edge of the wound. This is coated with liquid adhesive. The maggots are then put in the wound and covered with the screen cage which is tightly taped down, leaving the screen exposed. The tape should be applied in the manner of a basket splint in order to make pressure around the wound. If the screen is large, a narrow strip of adhesive may be drawn across the top to hold it firmly in place. If on an extremity, a snug bandage should be applied to hold the tape in place (Fig. 5). A pad is so placed as to catch the drainage from the wound but not to obstruct the access of light and air to the screen. The bandage and pad may be changed as often as necessary without disturbing the remainder of the dressing. The maggots are left in the wound for five days at each application, unless there is some indication for their removal at an earlier stage. If the drainage stops, the maggots are probably dead and should be removed, although the wounds do well even when the maggots are dead. Using a support for bed covers, a light may be placed to shine on the screen. The light drives the maggots deep into the wound and adds to the comfort of the patient. It should not be placed so close as to dry the secretions on the screen as this blocks drainage and results in quick death of the maggots. Between applications of maggots, a day's rest is given, the wound being tightly packed with dry gauze.

In all cases, there is a great tendency of the wounds to heal at the

outer edges. Often, if the outside opening is not particularly large, the wound will nearly close at the surface during one period of maggot treatment. In this case, a small glass tube about one-half inch in diameter and long enough to go nearly to the bone may be used (Fig. 4-*C*). The maggots then have access to the depths of the wound and good drainage is maintained. As the wound heals, a shorter tube may be used. The tube should be held in place with adhesive strips (Fig. 6). The usual dressing is applied over the wound.

Some workers report that the maggots live only a few hours in the wound after the first application and believe this is due to some substance secreted in the wound by the body or to some substance resulting from the maggots' own metabolism. It does not seem logical that the maggots would themselves produce a substance which would result in their death, and in nature maggots live to maturity in open wounds on live animals. I am of the opinion that, if the maggots die, it is a result of inadequate drainage. In culture, they die if too much moisture is present and if air is excluded. We have cases which have had many applications, in which the maggots live five days if good aeration and drainage are maintained. The progress of these cases is as satisfactory as any in which maggots have been used. I have seen the dressings of one worker who makes no effort to keep the maggots in the wound and merely covers the wound with a large gauze dressing. This dressing rapidly becomes soaked with secretion and it would be remarkable if the maggots did live long under it.

The usual advice is to completely fill the wound with maggots. This usually results in death of many of the maggots in a few hours because the drainage is blocked. If the maggots do live, they grow and crowd off the screen and escape, causing the patient great discomfort. I try to put in a number which I think will approximately fill the wound when they are at the adult stage of growth. This is about one-fourth to one-third of the wound volume when the maggots are at the three-day stage. The maggots rapidly seek out and devour all available food and continue working for a full five days.

After the bone is completely covered with granulations, the question of secondary closure of the wound arises. If the maggot treatment is continued, the wounds will eventually heal to skin level; and, in cases with only local bone involvement and a small wound, this is perfectly satisfactory and healing may be completed in as short a time as four weeks. In cases with extensive bone involvement and a wide incision, the healing is progressively slower and, near the end, may be completely arrested. One worker recently told me that the greatest difficulty was encountered in the final stages of healing of the soft tissues. If the wound does heal, the resulting scar is wide and thick, the circulation rapidly becomes poor, and, if subjected to trauma, it may break down. If secondary closure is done after all bone is healed over, the formation of a large mass of scar tissue is avoided, and the wound closes rapidly and with a much better cosmetic result. Certainly, the course of the treatment is greatly shortened and

subsequent breakdowns in the soft tissues are less likely to occur. It is not necessary to prepare the wound for closure other than to cleanse it with saline irrigations. If thought advisable, the wound may be dakinized or cleansed otherwise. In one case, we removed maggots and closed the wound on the second day thereafter. It remained closed after a few days of slight drainage. Like most secondary closures, these wounds usually partly break down and then heal rapidly.

SUMMARY

1. A method is presented by which maggots may be raised for use in a hospital or private practice.

2. Very little time is required in culture and growth of maggots by this method.

3. The expense for equipment is almost negligible since most of the apparatus is home-made.

4. If the maggots are properly applied, any slight discomfort to the patient is easily controlled.

5. If proper drainage is maintained, the maggots do not die in the wound.

6. Secondary closure of the wounds, after the bone is covered with granulation tissue, is advisable if the wounds are extensive or in a position exposed to trauma.

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THE USE OF COLLOIDAL SULPHUR IN THE TREATMENT OF ARTHRITIS

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The use, during the past two years, of intravenous and intragluteal colloidal sulphur in the form of sulphur diasporal, * in 250 cases, each receiving from ten to one hundred injections, has led the writers to believe that this material has a very definite place in the treatment of arthritis. (Clinical data soon to be published justifies this statement.)

As little could be found in the literature relative to the use of sulphur itself in the treatment of arthritis, it was felt that assurance as to the toxicity or non-toxicity of this product should be had at the beginning. Clinically, in the injection of several thousand doses there have been no unfavorable reactions to the material, except in one case. This, the investigators are firmly convinced, was a pseudoreaction or rather a simultaneous reaction from another cause. The patient herself, of course, felt the reaction to be due to the administration of the sulphur.

As the first phase of a multiphased piece of research which the investigators are carrying out, they wish to here present sufficient evidence that this preparation is found not harmful in clinical doses. In the present series of cases, investigation has been confined to the hypertrophic type of arthritis.

Several investigators have shown that the parenteral toxicity of colloidal sulphur depends upon its dispersion and the speed of injection, especially for intravenous administration [1, 2, 3, 4]. The relation between dispersion and toxicity is probably due to the fact that the toxic effects of colloidal sulphur are apparently dependent upon the rate and amount of H_2S formation *in vivo*. A finely divided sulphur preparation offers a much greater surface to the reducing action of the tissues, and consequently the rate of H_2S formation will be much higher than that of another preparation with less dispersion, and with less active surface of the sulphur particles. Because of this fact, Messini [1] found the toxicity of various colloidal sulphur preparations to vary from seven milligrams to 315 milligrams per kilogram of body weight (intravenously in rabbits). He also noted the effect of age and concentration of these preparations upon toxicity, which effects can be explained on the basis of dispersion changes.

Messini demonstrated that a distinct inverse relationship exists between the intravenous toxic dose and the injection time. The M.F.D. (minimal fatal dose) of one preparation varied between thirty-two and

* The material, sulphur diasporal, used in the investigation reported in these papers was donated through the courtesy of J. Doak Company, Inc., of Cleveland, Ohio.

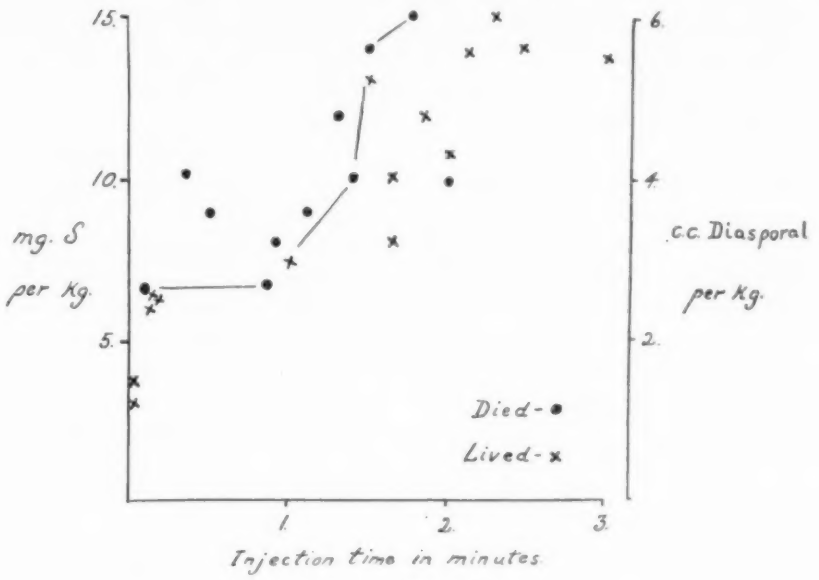

FIG. 1

This demonstrated the inverse relationship between the M.F.D. of aqueous sulphur diasporal and the time of injection, as administered intravenously in rabbits.

ninety-seven milligrams per kilogram of body weight (rabbit) with injection times of from one to nine minutes.

Because of these factors, the toxicity of a colloidal sulphur preparation cannot be judged entirely from its sulphur content, but must be determined experimentally.

Another important detail to be considered, concerning the intravenous administration of a colloidal substance, is colloidal shock: the so called "anaphylactoid shock" of Hanzlik and Karsner[5]. These workers showed that intravenous injection of such colloids as carbon, kaolin, etc., produced severe symptoms in experimental animals. Other investigators have reported [6, 7, 8, 10, 11, 12, 13, 14] on these facts also.

Sulphur diasporal is supplied in two forms: a two-cubic-centimeter ampule, stated to contain five milligrams of colloidal sulphur dispersed in a protein-free aqueous medium for intravenous medication, and a two-cubic-centimeter ampule containing twenty milligrams of colloidal sulphur dispersed in olive oil, for intramuscular injection. The term "sulphur diasporal" will henceforth be abbreviated to "S.D.".

The following are the findings of the writers relative to the toxicity of colloidal sulphur:

Four sets of experiments were carried on in animals.

Experiment 1 consisted of the injection of aqueous S.D. and intromuscular S.D. into the peritoneum of guinea pigs. The toxic dose of the aqueous S.D. ranged between thirty milligrams and 40 milligrams per kilogram of body weight. The toxic dose of the S.D. in oil (intragluteal)

is 220 milligrams per kilogram of body weight. The discrepancy between the toxicities of the aqueous (intravenous) and the oil solutions (intragluteal) is probably due to the more rapid absorption of the aqueous preparation and also, possibly, to its irritant effect.

Experiment 2 consisted of the investigation of the intravenous toxicity for rabbits. Here the toxic dose ranges from six and six-tenths milligrams of sulphur per kilogram of body weight, when injected in five seconds, to fifteen milligrams of sulphur per kilogram of body weight, when injected in 104 seconds.

The explanation for this relationship between toxicity and rapidity of administration may lie in the fact that the H_2S, formed from the action of blood on the sulphur, is excreted by the lungs, as has been proven by placing lead acetate paper over the animal's nostrils [1, 2, 3, 7, 8, 9]. When sulphur is administered rapidly, H_2S accumulates in the blood stream faster than it is removed, until it reaches a fatal level. During a slow injection, however, the H_2S may be excreted as rapidly as formed, and hence will not accumulate.

Experiment 3 consisted of the investigation of the effect of intravenous injections in an anaesthetized dog. Rapid injection produced a fall of blood pressure, which immediately rose a little above normal and then declined to normal level. When the material was injected slowly, no change was noted either in the blood pressure or respiration. An electrocardiogram showed no abnormality.

Experiment 4 consisted of the investigation of the chronic effect of intramuscular injection in dogs. This experiment indicated that no harmful effects were produced by this material even when given in rather large doses repeatedly over a long period of time. These laboratory findings seem to indicate that colloidal sulphur does not have any acute toxic effect. Moreover, except for unimportant local reactions no other investigators have reported deleterious effects, even in humans.

SUMMARY

The minimal fatal dose of the colloidal sulphur preparation (sulphur diasporal) used in the treatment of arthritis was determined by intraperitoneal administration in guinea pigs and intravenously in rabbits. The effects of intravenous administration on the blood pressure and respiration of dogs are reported, as well as the effects of a series of intramuscular injections. These toxicological studies would not indicate that this preparation is harmful in clinical doses.

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SHORT METATARSAL BONES AND THEIR RELATION TO POLIOMYELITIS

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This article deals with those cases in which one or more of the metatarsal bones from the second to the fourth is short relative to the others, with no evidence of other malformation, fracture, or disease. Such cases are usually referred to as congenital malformations, but this is rarely the cause of the shortening.

Forty-two of these cases of simple shortening were studied,—fourteen males, twenty eight females, aged nine to fifty-seven, average twenty-two. In fourteen cases each foot was affected. In the fifty-six affected feet the fourth metatarsal was short forty-three times, the third twenty-five times, the second twenty-two times. The short bones were from sixty to ninety-five per cent. of their proper length. The right foot was affected thirty-one times, the left twenty-five times.

One of these cases was seen at age seven. At this time there was no short metatarsal, although the whole right foot was underdeveloped due to poliomyelitis. This case was seen again at age eleven, at which time the right third and fourth metatarsals were only ninety-four per cent. of their proper length, the shortening being due to premature union of the epiphyseal lines. Obviously the deformity was not congenital in this case.

Twenty-seven of the forty-two patients were known to have had poliomyelitis, seven probably had had it, five may have had it, and three had no history or muscular weakness suggesting it. In two cases there were congenital club feet. It is evident that the deformity is usually a sequel of poliomyelitis, and the presence of the deformity is strong evidence that the patient has had that disease unless congenital club-foot is present.

To determine the relation of poliomyelitis to the development of this deformity the twenty-seven cases known to have had poliomyelitis were studied. In all of the cases in which the length of leg was recorded (nineteen), there was a short leg on the affected side, or on one side in bilateral cases. The shortening was from three quarters to three inches.

The anterior tibial muscle was completely paralyzed in twenty-one cases, weak in five, and strong in one (which showed only a trace of shortening of two metatarsals). In the fifteen cases not known to have had poliomyelitis, this muscle was completely paralyzed in three, weak in two, spastic in one. No other muscles of the leg were so constantly affected.

In the twenty-seven poliomyelitis cases, the paralysis occurred between the ages of nine months and five years, only three being more than

FIG. 1

Simple shortening of the right fourth metatarsal bone relative to the other metatarsals due to premature union of its epiphysis. Note that the proximal phalanx of each third and fourth toe is also short due to premature epiphyseal union. Female, aged ten.

three years old at the time of the attack, but no short metatarsal was noted under age nine.

Twelve of the poliomyelitis cases had had operations—such as subastragaloid fusion or astragalectomy—before a short metatarsal was noted, but when a short metatarsal bone was noted before an operation there was no subsequent change due to the operation.

It seems that shortening of the second, third, or fourth metatarsal bone appears early in adolescence, due to premature union of the epiphysis in patients who have had poliomyelitis early in life, usually before age four, with extensive paralysis of the limb at the time of the attack, and particularly when the anterior tibial muscle has been affected.

Examination of a number of poliomyelitis cases (including thirty patients over ten years of age), in which there was no relative shortening of a metatarsal, showed that they failed to meet the usual conditions in one or more of the following particulars:

1. Poliomyelitis did not occur before age four.
2. Paralysis in the leg had not been extensive and prolonged.
3. The leg was not short.
4. The anterior tibial muscle was not affected, or had rapidly recovered its power.
5. The patient had not reached the age of adolescence.

In poliomyelitis the whole foot may be underdeveloped but this does not prevent relative shortening of a metatarsal. Of the poliomyelitis cases in this series nine had underdevelopment of the foot.

It should be noted that the proximal phalanx of the toe is usually short when the metatarsal is short, but not always in the same degree. Also, the proximal phalanx may be short when the metatarsal is not affected (two cases). The shortening of the phalanx is due to premature union of the epiphysis.

SUMMARY AND CONCLUSIONS

Forty-two cases of simple shortening of the second, third, and fourth metatarsal bones were studied.

The deformity is a sequel of poliomyelitis in most cases and its presence is strong evidence that the patient has had that disease unless congenital club-foot is present.

The deformity tends to occur in those cases in which there has been extensive paralysis of a leg early in life (before age four) with involvement of the anterior tibial muscle, but the deformity does not appear until early adolescence, when the epiphysis unites prematurely.

In no case in this series did the deformity appear to be a congenital malformation.

AMPUTATION STUMPS OF THE LOWER EXTREMITY

BY MAJOR N. T. KIRK, WASHINGTON, D. C.

On the functional value of the stump alone, when properly fitted with the present-day prosthesis, must be based the selection of the site of amputation and the technique of the operative procedure. When contemplating an amputation, the surgeon should, therefore, not lose sight of the fact of the prosthetic limitations and requirements as to the type of weight-bearing,—the length and adaptability of the stump. The stump, then, must be formed to meet the requirements of weight-bearing and locomotion as required by available types of prostheses. It has been found that certain sites of amputation give better functioning stumps than others. Many of the older sites of amputations, as well as methods and technical detail found inferior, have been discarded.

Lisfranc disarticulated through the foot at the metatarsal-tarsal articulation, causing a muscle imbalance in the stump, due to partial loss of insertion of the tibialis anticus and peronei (Fig. 1).

Chopart disarticulated through the mid-tarsal joint, causing still greater muscle imbalance with loss of the ankle extensors, and thus forming an insecure stump which soon develops a persistent equinovarus deformity,—a stump which is usually painful and useless.

Sir James Syme of Edinburgh in 1843 first described the supramalleolar amputation, which bears his name. The saw line is one-half inch above the lower articular surface of the tibia and parallel to the long axis of the leg. A heel flap is dissected from the os calcis and brought up over the bone end. When successful, it provides a stump, fully end-bearing, trans-

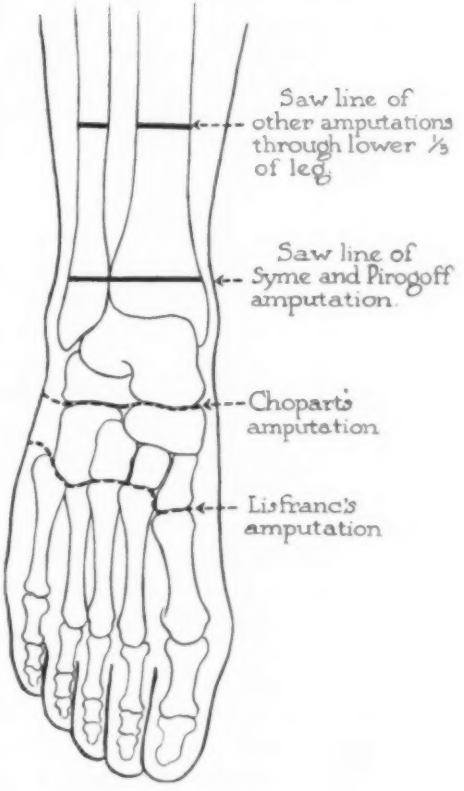
Saw line of other amputations through lower ⅓ of leg
Saw line of Syme and Pirogoff amputation
Chopart's amputation
Lisfranc's amputation

FIG. 1

Sites of amputations accepted by many authorities as giving ideal stumps. Considered inferior by the author from a functional standpoint, except on rare occasions, to an amputation through the lower part of the middle third of the leg.

mitting the entire body weight without pain, which can be used without the aid of a crutch or prosthesis for a limited distance in case of emergency. Unfortunately, all Syme's stumps are not ideal, usually the result of faulty surgical technique. Frequently there is a redundancy in the stump end, which is difficult to prevent, and which causes instability as it rolls under the bone of the stump end. If infection follows or the circulation of the heel flap is interfered with in the dissection, the stump fails. Huggins states that the Syme's stump, which is not entirely end-bearing, is inferior from a functional standpoint to an amputation through the leg. He finds such stumps not uncommon.

Pirogoff modified Syme's technique by leaving the posterior part of the os calcis in the heel flap, thereby producing an osteoplastic amputation. This was devised, not primarily as an osteoplastic procedure, but to overcome the difficulties in dissecting the os calcis and the incident necrosis from interference of blood supply in the formation of Syme's stump. It has the advantages of the Syme's stump in direct end-bearing, but further disadvantages from a prosthetic standpoint. The stump end in both these amputations is bulbous, making the prosthesis very apparent and unsatisfactory at the ankle. Due to their lengths, they are fitted with difficulty by the average prosthetist. The objectionable thigh cup and shoulder straps required by the usual below-knee prosthesis, however, do not have to be used. The best type of Syme's prosthesis I have seen was described by LeMesurier in *The Journal of Bone and Joint Surgery* for April 1926 (VIII, 292). The Pirogoff stump is so long that an ankle joint cannot be incorporated in the prosthesis without its making the extremity longer than the normal leg. A Syme's amputation should be considered in the laborer who has to be on his feet continually, or in one who cannot afford to buy the present-day prosthesis. Conditions requiring amputation of the leg will in the greater number of cases fall above the Syme's line, however.

An amputation through the lower third of the leg gives an unsatisfactory stump. The tibia at this level has no muscle insertions and is covered mainly by tendons. The circulation of the skin is poor, it tends to become cyanotic, heals poorly, and is easily traumatized. The length interferes with the ankle mechanism in the shin piece of the prosthesis. It possesses no advantages because of its length.

It is believed that the stumps giving the best functional value below the knee are obtained by amputation either through the bases of the metatarsal bones beyond the insertion of the leg muscles, or through the middle third of the leg, giving a stump length of not more than seven inches or less than five and one-half (Fig. 2).

The site of election in the leg amputation is through the middle third. The technique of the operative procedure to form an ideal stump at this or a higher level is as follows (Fig. 3):

The saw line is selected, measuring from the insertion of the internal hamstring tendons when the knee is flexed to a right angle. The fibula is

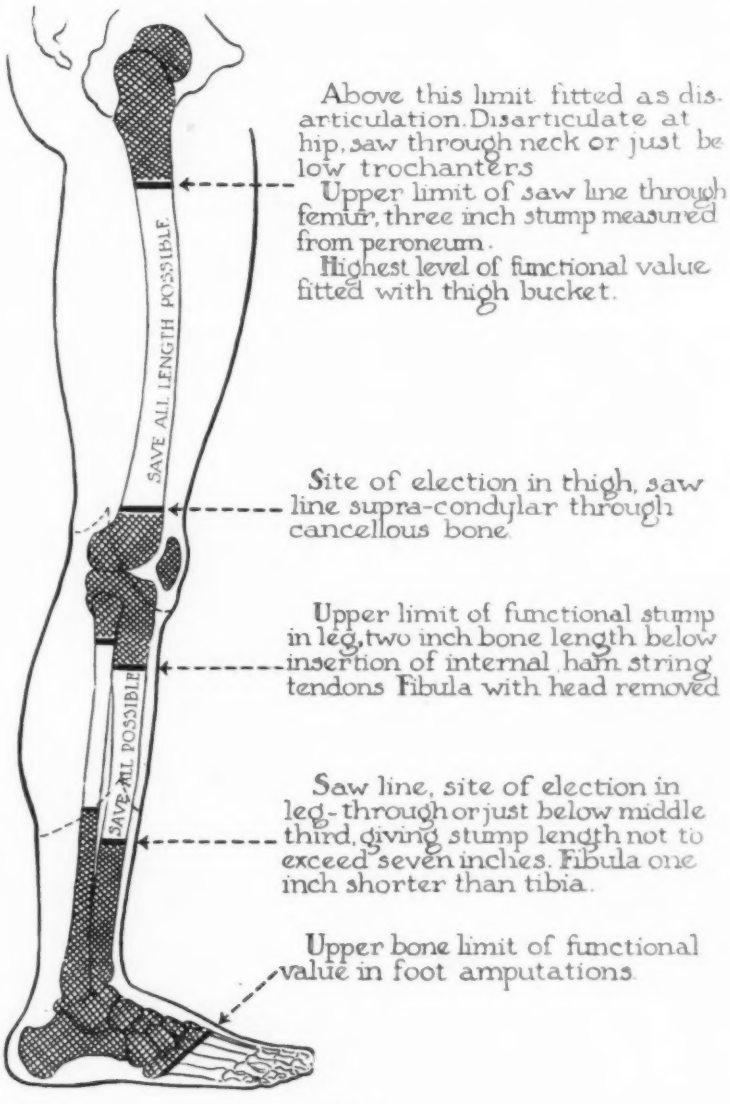
Above this limit fitted as disarticulation. Disarticulate at hip, saw through neck or just below trochanters
Upper limit of saw line through femur, three inch stump measured from peroneum.
Highest level of functional value fitted with thigh bucket.
SAVE ALL LENGTH POSSIBLE
Site of election in thigh, saw line supra-condylar through cancellous bone
Upper limit of functional stump in leg, two inch bone length below insertion of internal ham string tendons Fibula with head removed
SAVE ALL POSSIBLE
Saw line, site of election in leg - through or just below middle third, giving stump length not to exceed seven inches. Fibula one inch shorter than tibia.
Upper bone limit of functional value in foot amputations

FIG. 2

Sites of election, lower extremity, giving best functional value.

sawed one inch shorter than the tibia, and, in the short below-knee stump, is removed *in toto* with its periosteum. Anterior and posterior skin flaps are formed in relation of three to two as to length. The anterior skin flap begins in the mid-lateral axis of the leg, extends downward, and slopes gradually across the front of the leg and backward to the mid-lateral axis of the other side. The incision begins just above the selected saw line and is carried through the skin only. This flap is dissected back to the saw line. The posterior skin flap is similarly cut, and is dissected back for about

one-half inch. The skin on the posterior surface of the leg, distal to the posterior skin flap, is cut away for two to three inches. The fascia so far has not been disturbed. The anterior skin flap is retracted to the saw line. The fascia and the muscles between the tibia and fibula, made up of the anterior tibial group of muscles, are cut through so that they will retract to the saw line. A long-bladed amputating knife is thrust through the muscles at the saw line just behind the fibula, coming out through the muscle posterior and against the tibia. A long muscle-tendon-fascia flap, triangular in shape, is formed from the posterior muscle group, which

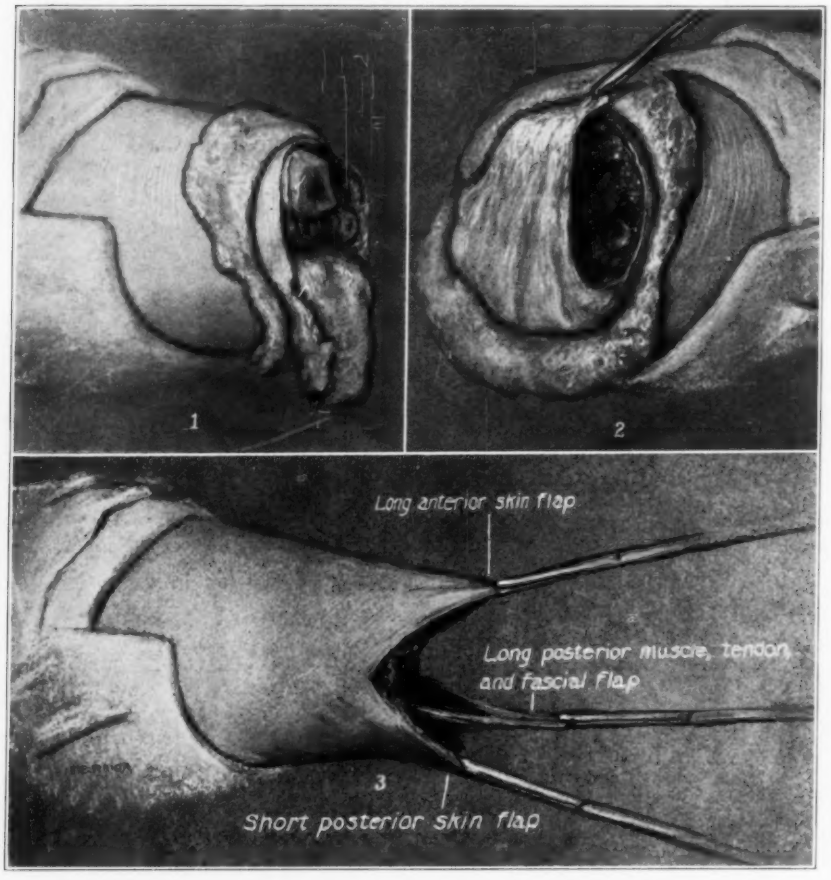

FIG. 3

Diagram of amputation through middle third of leg.

1. Anterior and posterior skin flaps turned back. Tibia sawed through and crest beveled. Fibula has been cut shorter than tibia. Long posterior muscle-tendon-fascia flap. Fascia and muscle between tibia and fibula on anterior lateral surface of leg has been cut to retract to the saw line.

2. Posterior muscle-tendon-fascia flap pulled up over stump end. Apex covers beveled crest of tibia. Inner margin in contact with mesial surface of tibia, and outer margin ready for suture to muscle and fascia between tibia and fibula. A rubber tissue drain is inserted under this flap.

3. Flaps pulled down by forceps to show relative length and position.

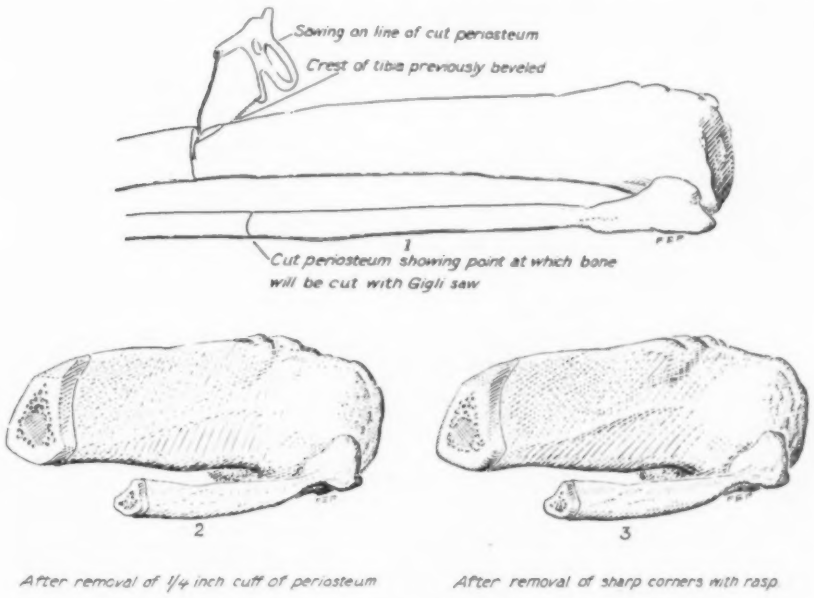
Sawing on line of cut periosteum
Crest of tibia previously beveled
1
Cut periosteum showing point at which bone will be cut with Gigli saw
2
After removal of 1/4 inch cuff of periosteum
3
After removal of sharp corners with rasp

FIG. 4

Diagrammatic representation of the various steps in an aperiosteal amputation through the middle third of the leg. *2* and *3* are foreshortened to show the bone end to better advantage. A one-quarter inch cuff of periosteum has been removed and the edges smoothed off with a rasp. The endosteum has not been disturbed.

includes the origin of the tendo achillis, by cutting downward and backward. It is cut sufficiently long to cover the stump end. The periosteum is cut circularly around the tibia at the saw line and above this level at the point where the crest of the tibia later will be beveled. The muscle is cut away from the fibula to an inch above the saw line of the tibia and the periosteum is cut through circularly around the bone. The soft parts are gently retracted. The crest of the tibia is beveled, and the tibia sawed through at right angles to the long axis of the leg. The fibula is sawed through with a Gigli saw. The periosteum is cut circularly around the tibia and its beveled crest, and from the fibula one-fourth inch above the saw line, and removed, care being taken not to shred it. The sharp corners of the tibia are rounded off with a rasp. Sharp bone-cutting forceps are used to better advantage in rounding off the fibula. If the tibia is not rounded off, there will be three sharp points to protrude through the skin, instead of the one originally presented by the tibial crest before it was beveled (Fig. 4). All bone dust and periosteal fringes are washed from the muscle with a flush of normal salt solution.

The posterior muscle flap is thinned down by cutting away the muscle substance from its anterior surface, so that it will not be more than one-quarter inch thick at its base and one-eighth inch thick at its apex. The flap is brought up into position over the bone end and properly trimmed to fit. The inner border of the flap will eventually be sewed to the fascia

FIG. 5

The ideal below-knee stump amputated at site of election by method here described.

and periosteum covering the inner surface of the tibia. The outer border will be sutured to the cut fascia and muscle between the tibia and fibula and the apex of the flap will be pulled over to cover the beveled crest of the tibia. The anterior and posterior tibial and the peroneal arteries are located and ligated. The anterior and posterior tibial, and the musculocutaneous nerves are secured, pulled down while the muscle is retracted, tied with plain catgut, injected with absolute alcohol, cut with a sharp knife, and allowed to retract. The musculocutaneous nerve runs parallel to and between the deep fascia and the muscles on the outer side of the fibula.

The tourniquet is removed and all bleeding arrested. The triangular posterior muscle-tendon-fascia flap is brought up into position from behind and held in place by a towel clasp. As stated above, the inner side of the flap is sutured with interrupted catgut to the periosteum and the fascia covering the inner surface of the tibia, the outer side to the fascia and the anterior tibial group of muscles between the tibia and the fibula which were originally cut to retract to the saw line. The tip of the flap is pulled over and covers the beveled crest of the tibia and is secured by suture in this position. A rubber tissue drain is inserted under the muscle flap and emerges through the suture line from the outer side of the wound. The skin flaps, after being reshaped if necessary, are sutured under slight tension with interrupted non-absorbable suture.

A sterile gauze dressing is applied, the stump tightly bandaged and covered with a cotton gauze pad. A posterior, well padded, board splint, extending from the upper third of the thigh to beyond the stump end, fixes the knee in extension. The drain is removed when the stump is first dressed at the end of forty-eight hours. To prevent flexion contractures in the knee, the splint is maintained in position until the wound is healed. Such splinting is necessary in all below-knee amputations.

This technique gives an ideal stump with the suture line just posterior to the bone end, without redundant soft parts, ideal in length, with freely movable skin (Fig. 5). The bone end soon becomes rounded off, painless,

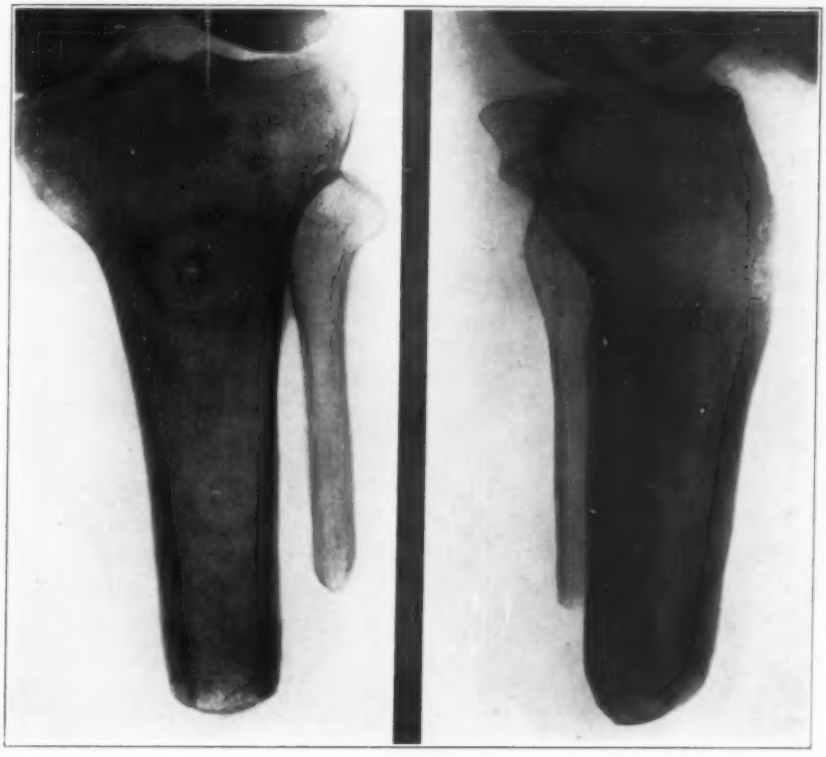

FIG. 6

The bone end of a below-knee stump using the aperiosteal method. It is rounded off, there are no spurs, and it is painless.

and free from spurs (Fig. 6). There is no large pad of muscle tissue to postoperatively pull away from the anterior surface of the stump, where it was sutured, or later to become a degenerated mass of oedematous, tender, and painful scar tissue. This stump is ready for fitting with its prosthesis six weeks following amputation, when healing occurs by primary intention. It takes its bearing on the shelving inner surface of the tibia below the tibial spine, and is reenforced by cone or lateral surface-bearing. This type of weight-bearing is inferior to end-bearing as afforded by the Syme's stump.

The thigh, like the leg, is roughly divided into thirds. The stump length is measured from the crotch to bone end of the stump. The functional value in the thigh stump rapidly diminishes above the lower third, due to the fact that at this level an end-bearing stump can be formed and so fitted. Either the Gritti-Stokes or the supracondylar tendoplastic method may be employed. Gritti in 1857 described his supracondylar osteoplastic amputation, which was slightly modified by Stokes in 1870. It is an osteoplastic method of amputation, in which the patella, after its articular cartilage is removed and its posterior surface made flat, with its covering soft parts and attached quadriceps tendon, is fitted to the sawed

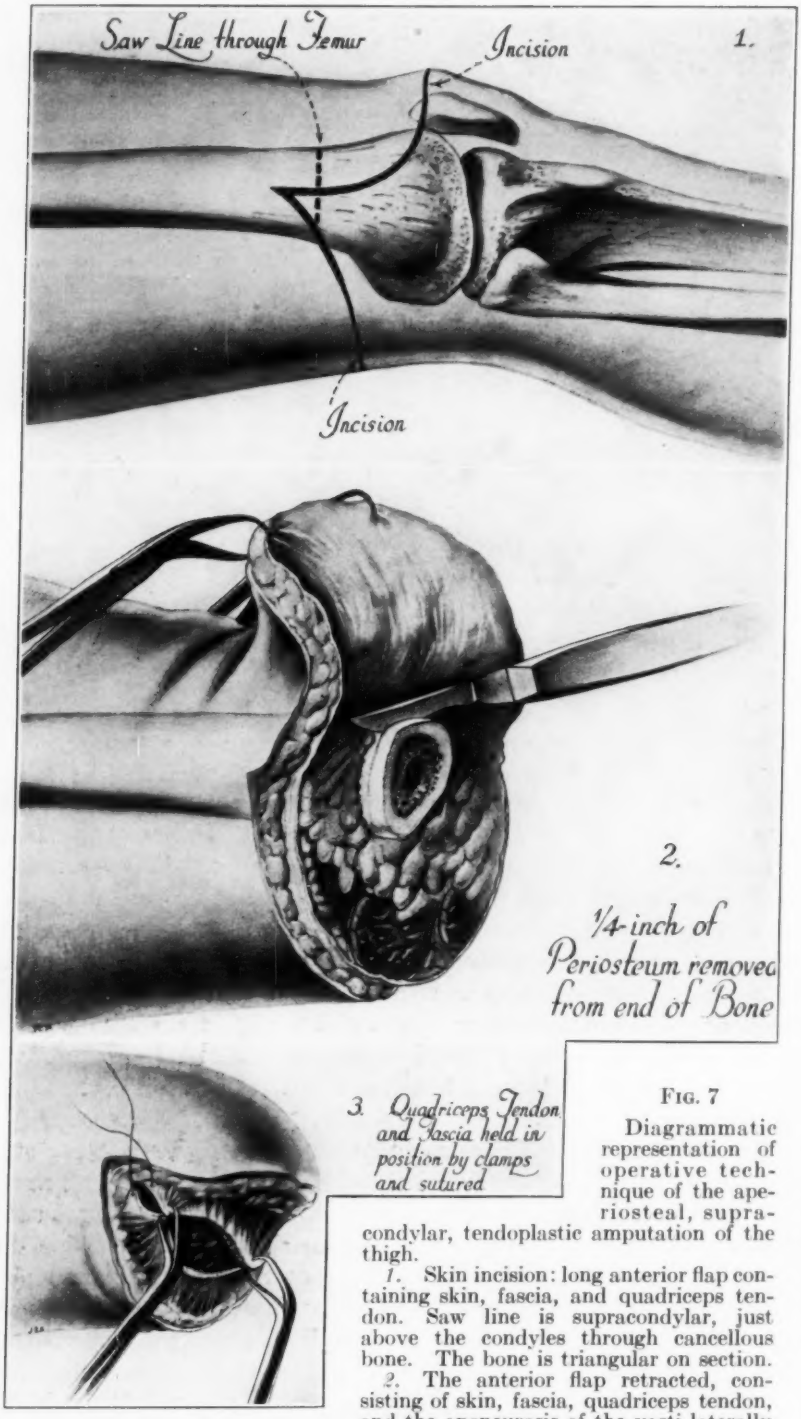
Saw Line through Femur
Incision
1.
Incision
2.
¼-inch of Periosteum removed from end of Bone
3. Quadriceps Tendon and Fascia held in position by clamps and sutured

FIG. 7

Diagrammatic representation of operative technique of the aperiosteal, supracondylar, tendoplastic amputation of the thigh.

1. Skin incision: long anterior flap containing skin, fascia, and quadriceps tendon. Saw line is supracondylar, just above the condyles through cancellous bone. The bone is triangular on section.

2. The anterior flap retracted, consisting of skin, fascia, quadriceps tendon, and the aponeurosis of the vasti laterally as they join the tendon. The fascia posteriorly is cut a quarter of an inch

FIG. 7. (*Continued*)
longer than the skin. A quarter-inch cuff of periosteum is removed and the bone end rounded off with a rasp.

3. The quadriceps tendon and its lateral aponeurosis are secured in their proper position to the fascia posteriorly with towel clamps until sutured. The quadriceps tendon is brought directly over the bone end. A rubber tissue drain is placed under the muscle-tendon flap.

end of the femur. When successful, it is wholly end-bearing. Its success depends upon bony union of the patella with the femur in proper position. Delayed union, tilting of the fragment, spur formation, necrosis, or infection means failure. This stump cannot be fitted with its prosthesis until bony union occurs.

The supracondylar tendoplastic operation, likewise, gives a full end-bearing stump. Success is not dependent upon bony union, which is a factor to be considered in all osteoplastic amputations, and the operative procedure is simpler and less time-consuming than the Gritti-Stokes. It is ready for fitting with its prosthesis in from five to six weeks after amputation. Wilms in 1902, after sawing through the femur, covered its end with the quadriceps extensor tendon, which he sutured to the periosteum on the posterior surface of the femur. The technique of the supracondylar tendoplastic amputation follows (Fig. 7):

This is an aperiosteal amputation through the supracondylar portion (metaphysis) of the femur. The quadriceps tendon, which is included with a long anterior skin flap, is cut close to its insertion into the patella, brought over the end of the sectioned femur, and sutured to the fascia posteriorly. The saw line is supracondylar, one to one and one-quarter inches above the upper edge of the articular cartilage on the anterior surface of the femur. The femur at this level is triangular in shape from the flare of the condyles, and is flat anteriorly. The saw line is through the cancellous bone of the condyles, below the medulla of the shaft. A tourniquet is applied around the thigh.

The skin incision to form the anterior flap begins just above the saw line in the mid-lateral long axis of the femur, extends downward, gradually swings across the anterior surface of the thigh just below the upper margin of the patella, and back up the other side of the thigh in like manner to just above the

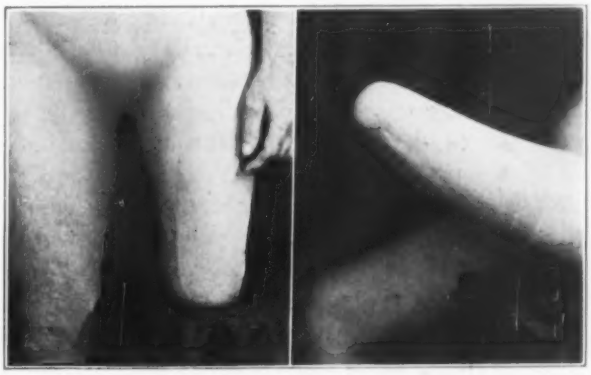

FIG. 8

The ideal thigh stump, end-bearing, the result of a supracondylar tendoplastic aperiosteal amputation. The suture line is posterior. It is wholly weight-bearing at the end of six weeks, painless, and fitted with its prosthesis.

saw line in the mid-lateral long axis of the femur. The skin incision is now carried posteriorly with a convexity downward, so that it will retract to the saw line. The anterior incision is deepened to the bone at the edge of the retracted skin, and the quadriceps tendon cut away from the patella at its insertion into that bone. This U-shaped flap, consisting of skin, fascia, quadriceps tendon, and muscle tissue joining the tendon laterally, is now lifted up and all of the suprapatellar bursa dissected out underneath. The fascia is cut posteriorly one-quarter inch longer than the retracted skin flap. Other muscle and soft parts are cut so that they will retract to the saw line. The soft parts are gently retracted so as not to detach the periosteum. The periosteum covering the bone at the saw line is cut through circularly with a knife and the bone sawed through at right angles to the long axis of the thigh. The periosteum is cut circularly around the bone, one-quarter inch above the sawed end, and this cuff of periosteum is carefully removed, shredding being prevented. The bone end is rounded off with a rasp and the bone dust and any periosteal shreds are removed by a salt-solution flush.

The femoral vessels are isolated and doubly ligated with plain catgut. Three knots are always tied in the catgut ligature to prevent its slipping. The sciatic nerve, which at this level may have divided into the internal and external popliteal, is isolated, pulled down while the muscles are retracted, ligated with plain catgut, using a needle to transfix the sheath so that the ligature will not slip, injected with absolute alcohol above the tie, cut with a sharp knife, and allowed to retract. The tourniquet is removed and all bleeding arrested. If the flaps have been properly cut, the anterior U-shaped flap of skin, fascia, tendon, and muscle will fit snugly over the bone end, forming a suture line with the fascia and skin on the posterior surface of the thigh, throwing the suture line posterior to the bone end. The anterior fascia-tendon-muscle flap is fixed to the posterior fascia of the thigh with towel clamps to secure position until sutured. The quadriceps tendon is placed directly over the bone end. This layer is now sutured with plain catgut; chromic gut is not necessary. The skin is closed with silkworm-gut, tension-type sutures being used.

A rubber tissue drain is placed under the fascia-tendon-muscle flap posterior to the bone end. The stump is dressed with sterile gauze, bandaged tightly, and covered with gauze and cotton pads. Skin traction for a few days will relieve any redness or tenderness in the stump end that may develop due to the pull of the quadriceps tendon against the bone end.

This method gives an ideal stump, full end-bearing in all cases, symmetrical in contour, free from spurs, and of maximum functional length. The medullary canal is not opened, and the quadriceps muscle group and the tensor fasciae femoris are securely anchored. The hamstring tendons are caught in the posterior sutures. It is applicable in a complete ankylosed knee joint and requires no skin below the middle of the patella. It has proven so satisfactory that it is considered the method of choice

where a satisfactory below-knee stump cannot be obtained. Full weight-bearing has been obtained as early as three weeks after amputation (Fig. 8).

No originality is claimed for the surgical technique of the two stumps just described. These methods have been used by me since 1919 and have been found entirely satisfactory. It is not believed that their functional value when properly fitted with a prosthesis can be improved by other operative procedures.

SUMMARY

1. Sites of election for amputation in the lower extremity from a functional standpoint are:

The bases of the metatarsal bones in the foot.

Middle third of the leg.

Supracondylar in the thigh.

2. The surgical technique of the mid-leg amputation and of the supracondylar tendoplastic amputation is described.

3. The aperiosteal method is considered the method of choice in the closed amputation.

4. Large muscle pads over the stump end are objectionable.

Certain of these illustrations have appeared in the chapter on "Amputations", written by the author for Dean Lewis's Practice of Surgery (Vol. III, Chap. 10, 1929) and are used by the courtesy of the publisher, W. F. Prior Company, Inc., Hagerstown, Maryland.

CERTAIN ARTHRITIC DISTURBANCES ASSOCIATED WITH PARATHYROIDISM * †

BY ROBERT V. FUNSTEN, M.D., UNIVERSITY, VIRGINIA

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A survey of arthritic cases has been made in order to isolate those which might fit into the parathyroid group. Ninety-five cases of arthritis, chiefly of the ankylosing type, were examined. Twenty-six of these showed symptoms suggestive of parathyroidism. The development of arthritis in the presence of parathyroid disturbance is a common occurrence, and is frequently responsible for the first symptoms.

CLINICAL DIAGNOSIS

Several cases were striking in their histories and in the ultimate findings and results. The general appearance of the patient, his prolonged history of pain, weakness, and stiffness in the joints, particularly the spine, is the outstanding clinical symptom suggesting further investigation. The pain is usually not relieved for any considerable time by orthopaedic methods.

The next most important finding is the characteristic demineralization of the spine, long bones, and skull as shown by x-ray examination. Even in the moderately advanced case there is calcium absorption in excess of the amount to be expected from disuse (Figs. 1 and 2). The roentgenograms of the skull show "granular" changes, which in the more advanced cases may even reach an appearance suggestive of Paget's disease as shown in Figures 3 and 4. In the early stages the arthritic findings in the spine may be mild as compared to the muscular weakness (Fig. 5).

Paroxysmal abdominal pains may be present. These pains are so severe in some instances that they can be relieved only by morphin. They disappear so rapidly following parathyroidectomy that they can scarcely be considered the result of mechanical irritation of the nerve roots. In one instance, a case, later diagnosed as parathyroidism, came to the clinic after having been discharged elsewhere as a morphin addict.

Although the determination of the calcium content of the blood and the calcium excretion in the urine is of considerable importance in confirming the diagnosis, still the disease in this respect simulates to some extent the picture of gout. The calcium shower into the blood is apt to be paroxysmal just as is the pain. It is often necessary to repeat the calcium determination many times for a true picture of the disease.

* From the Orthopaedic Clinic at Harper Hospital, Detroit, Michigan.
† Presented at the Annual Meeting of the American Orthopaedic Association, Toronto, June 16, 1932.

FIG. 1

Roentgenogram of a man seventy-five years of age with extensive hypertrophic changes, but little atrophy.

FIG. 2

Hypertrophic arthritis of the spine with atrophy characteristic of parathyroid disease.

FIG. 3

Extensive Paget's disease of skull.

FIG. 4

Skull in moderately advanced parathyroid disease, showing granular appearance of inner table.

Most of the cases have shown a blood calcium of high normal (10.2 milligrams per 100 cubic centimeters), and in one case it reached the high point of sixteen milligrams per 100 cubic centimeters.

If the calcium intake is properly regulated, the urinary excretion of calcium is a more nearly consistent index. According to Hunter as well as Compere, a normal individual on a low calcium diet excretes about one-tenth milligram per 100 cubic centimeters in a twenty-four hour specimen, whereas, on an average calcium diet it may reach five-tenths milligrams per 100 cubic centimeters. In the parathyroid syndrome it may go as high as three times the normal amount.

Additional evidence of parathyroidism has been obtained through electrical stimulation of the muscle by means of the chronaximeter, which gives the optimum *closing cathodal-contracture* for the minimum time element. This, for the flexor of the little finger, is normally .00032, whereas, in parathyroidism the index may be .00038 or 0.0050.

FIG. 5

Characteristic rounding of shoulders in parathyroid arthritis.

In the electrocardiogram reading, as shown by Dr. E. D. Spalding of Harper Hospital, the R-T interval is shortened. This is normally .00026 to .00028 seconds. In parathyroidism it is .00022 or less.

The irregularity in finding the characteristic blood and urinary pictures has led in several instances to a delay in diagnosis, which was not reached until x-ray evidence had become conclusive in itself. The following case brought this to my attention:

William C., aged twenty-four, reported to the dispensary May 3, 1929, complaining of stiffness and pain in the back and hips. This had gradually increased for a period of two years. During treatment his tonsils and all his teeth had been removed without improvement.

Examination showed a round-shouldered individual with a marked limitation of motion and tenderness over the spine and sacro-iliac joints. Roentgenograms (Fig. 6) showed spurring of the lower lumbar segments, diminution of the disc between the fourth and fifth lumbar vertebrae, and obliteration of the sacro-iliac joints as well as the articular facets.

No calcium determination was made until December 1930, nineteen months after admission. Three determinations showed practically a normal calcium metabolism. The basal metabolism was minus twelve.

In the meantime, he developed more severe pain, limitation of motion, and muscle spasm in the left hip. A plaster spica was applied. This at first gave almost complete relief, but after a few weeks had to be removed because of increasing pain. He was again admitted to the hospital in January 1931. At that time his spine and hips had stiffened to such an extent that it was necessary for him to sleep in a sitting position.

Every source of infection was investigated without any positive findings. Lumbar ganglionectomy was performed by Dr. Frederick Schreiber for relief of the pain. Patient was considerably improved for about three months and was able to walk several blocks on crutches without much pain. However, pain of a paroxysmal character recurred and he was readmitted to the hospital in December 1931. At that time the blood calcium was as high as twelve milligrams and the phosphorus as low as two and six-tenths milligrams. The chronaxia was slightly above normal. Roentgenograms then showed marked demineralization of the dorsal and lumbar spine with reduction of the size of several of the dorsal vertebrae. The arthritis had progressed. The skull had a "granular" appearance. Two parathyroid bodies were removed on December 16, 1931, by Dr. Ballin. These showed adenomatous changes. Within forty-eight hours after operation, motion was freer in the joints and pain was considerably relieved. The calcium gradually returned to normal. After six months, roentgenograms showed an increase in the calcium content of the spine and arrest of the progress of the arthritis. An instance of the misappropriation of calcium was noted in this case. A calcified mass developed in the parotid gland which was expressed after several attacks of swelling.

Another case, Mrs. R. M., aged fifty-seven, complained of severe backache for four years, unrelieved by orthopaedic treatment. Roentgenograms showed thinning of the intervertebral discs, the ankylosing type of arthritis, and general demineralization (Fig. 7). The blood calcium ran as high as fourteen and six-tenths milligrams and phosphorus

FIG. 6

Lateral view of arthritic spine, showing characteristic demineralization.

FIG. 7

Roentgenogram showing hypertrophic arthritis in the presence of extensive demineralization.

two and ninety-five hundredths milligrams. Two adenomatous parathyroids were removed on February 9, 1931, by Dr. Ballin and almost immediate relief of pain was experienced. This has continued until the present time.

A typical case of spondylitis connected with parathyroid disease is shown in that of Mrs. R. McA., aged twenty-six. She has always been round-shouldered, possibly as a result of early epiphysitis, but developed severe pain and stiffening of her spine following pregnancy (Fig. 8). She was treated by conservative orthopaedic methods for several months without relief. Roentgenograms showed a mild generalized spondylitis with narrowing of the bodies of the sixth, seventh, and eighth dorsal vertebrae and thinning of the intervertebral discs. Two parathyroids were removed by Dr. Ballin on May 18, 1931. Following this, there has been complete relief of backache which has continued to the present time. Because of the severe deformity, she was placed on a hyperextension Bradford frame, with great improvement of the deformity.

In several of the cases there has been a removal of part or all of the thyroid in addition to parathyroid tissue. Since there has been a considerable amount of discussion as to the rôle of these two glands

FIG. 8

Typical posture in parathyroid arthritis.

in the production of arthritis, it seems well to point out one case in our clinic in which the parathyroid syndrome manifested itself in a moderately high blood calcium, ankylosing arthritis of the spine and hips, and a calcification of the femoral trochanteric bursa. This patient left the clinic and went to another hospital where an adenomatous thyroid gland was removed without any improvement in symptoms. She did not get the rapid relief of pain and the sense of relaxation in the joints, which seems to be characteristic of parathyroidectomy.

Parathyroidectomy was done in fourteen of the twenty-six cases. Only one of the cases operated upon failed to show improvement. This young woman had cervical arthritis with radiculitis.

Nine cases showed marked improvement. Within a day or two following operation, the sensation of stiffness in the joints began to disappear and there was less pain and more ease of motion. They were classified as markedly improved only when entirely free from pain and when the roentgenograms showed an increased density in the bones. Four cases were moderately improved.

The shortest postoperative observation was four months. The longest period of observation has been eighteen months.

Twelve cases were treated conservatively with cod-liver oil concentrate, calcium gluconate, physiotherapy, and orthopaedic appliances. Of these, five were much improved, three were moderately improved, and four showed no improvement.

CONCLUSIONS

1. Arthritis is very common in parathyroid disease.

2. Parathyroid disease is frequent in arthritis, either as a primary cause or secondarily as the result of a common etiological factor. It may be recognized by symptoms of paroxysmal pain in the spine and abdomen, deformity of the spine, and x-ray evidence of demineralization.

3. The diagnosis may be substantiated by means of repeated blood and urine calcium determinations and chronaxia.

4. There is almost immediate relief of pain and a feeling of relaxation in the joints following parathyroidectomy.

5. In the milder cases, when it is not possible to make an absolute diagnosis and in poor surgical risks, treatment by means of cod-liver oil concentrate and calcium gluconate accompanied by conservative ortho-

paedic treatment may lead to improvement and arrest of the disease, at least temporarily.

6. The operations for the removal of the parathyroids, all of which have been performed by Dr. Ballin, have not been accompanied in any instance by tetany or shock, and can be considered sufficiently harmless to justify the procedure in even the milder cases.

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PARATHYROIDISM IN REFERENCE TO ORTHOPAEDIC SURGERY*

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Parathyroidism due to hyperplastic or adenomatous conditions of the parathyroid glands has become a recognized entity. Its main symptoms are an elevated serum calcium with some decrease in the serum phosphorus, increased calcium and phosphorus output in urine and feces, larger than the intake, and, therefore, a negative calcium and phosphorus balance. It is of the utmost importance to understand that this surplus of calcium in serum and excretions under the influence of increased parathyroidal function is taken from the skeleton; therefore, decalcification of the bones, osteoporosis and late retrogressive changes, osteitis fibrosa cystica, bone cysts, osteoclastic processes, giant-cell tumors, deformities, and pathological fractures of the softened bones are sequelae of increased parathyroid function,—that is, parathyroidism. These are all facts now verified by ample clinical observations, by the cure of the conditions accomplished by removal of the hyperplastic or adenomatous parathyroids, and by the experimental production of the same features mentioned through injections of parathyroid extract. The skeleton is the main organ affected by parathyroidism. (We have used in our writings the shorter word, parathyroidism, instead of hyperparathyroidism as it covers just as much.) For this reason the subject is of paramount importance to the orthopaedic surgeon. Nevertheless, besides the skeletal changes, the upset in calcium and phosphorus metabolism also causes gastro-intestinal and urinary symptoms, metastatic calcium deposits, and muscular hypotonia. While these latter symptoms are not of direct importance to orthopaedic work, they are worth mentioning for diagnostic purposes and clinical understanding.

The connection between parathyroidism and skeletal changes was brought out first by the frequent autopsied findings of skeletal changes with parathyroid tumors. Erdheim[1] and Barr, Bulger and Dixon[2] have collected forty-five such cases, and we know of a few more, where osteomalacic conditions, especially osteitis fibrosa cystica, if looked for, were nearly always found together with hyperplasias or adenomas of the parathyroid.

Numerous experiments have now been made, showing that repeated injections or overdoses of parathormone will produce decalcification of the skeleton, typical osteitis fibrosa cystica with osteoclastic processes and giant-cell formation, hypercalcinuria, intestinal upsets, great muscular weakness, and, in poisonous doses, death from these symptoms. These same conditions we see in human beings suffering from para-

* Read before the American Orthopaedic Association, Toronto, Canada, June 16, 1932.

FIG. 1

H. J. B., sixty-three years old. Compression of vertebrae. Was diagnosed metastatic malignancy. Calcium 14 milligrams. Parathyroidectomy brought complete relief. Outline of vertebrae retouched. Lived two years in comfort. Died from uraemic condition. Nephritis preceded parathyroidectomy and was due to hypercalcaemia.

FIG. 2

R. C., fifty-six years old. Practically the same symptoms, diagnosed myeloma in this case. Had to use codein for pain. Note compressed vertebrae at arrow.

FIG. 3

Same case as Fig. 2, nearly one year after parathyroidectomy. Clinically cured eighteen months after operation. Note compressed vertebrae at arrow.

FIG. 4

M. R., female, forty-nine years old. Diagnosed compression fracture of lumbar vertebrae. Six months later entered Harper Hospital in ambulance in excruciating pain; could hardly move; showed several such compressed vertebrae. Calcium 14 milligrams. Removal of parathyroid adenoma gave complete relief.

thyroidism (Collip[3], Wilder[4], Jaffe and Bodansky[5]). Very recently J. L. Johnson[6] has published a most interesting paper, showing beautiful examples of such osteitis fibrosa cystica artificially produced in dogs. He comes to the conclusion: "This experimental disease, produced with repeated injections of parathormone, is characterized by skeletal lesions and other abnormalities which correspond closely to those observed in clinical cases of osteitis fibrosa osteoplastica (von Recklinghausen)".

About the clinical observation, we were able to collect from the literature and from our own recent experiences 100 cases of parathyroidectomies followed, except for a few surgical mortalities, with good results in every case in which the parathyroids or parathyroid tumors were removed. In a few of the 100 cases parathyroids were not found; four patients died, three of these from postoperative tetany. These deaths are practically all avoidable under the methods we have since learned, consisting of proper technique in leaving one or, better, two functioning parathyroids, and proper postoperative care in preventing the sudden disturbance of parathyroid function. In our own forty-five cases, up to date we have not had a fatality. The results of operation we will take up in going over the different types of the disease of interest to the orthopaedic surgeon.

We distinguish the following types:

1. The vertebral form, mainly expressed by kyphosis and compressed vertebrae, usually slow in progress.
2. The infantile type, usually more rapid.
3. The arthritic type.
4. The Paget type.
5. Types where muscular hypotonia or gastro-intestinal symptoms are more prominent than the skeletal.

All five groups overlap each other and cannot be strictly separated.

People of all ages seem to be subject to the disease. It is surprising in looking over the tabulations we made of these 100 cases to note in how many cases the disease started early in life, in some even in infancy. The vertebral form in mid-life seems to be the most frequent one unless it be the arthritic form, of which Dr. Funsten has spoken to you, and which will receive the attention and recognition it deserves

FIG. 5

J. B., female, sixty-one years old. Compressed vertebrae, expansion of nucleus pulposus causing cupping of vertebral bodies. Severe pain. Clinical relief of pain by parathyroidectomy.

1. The vertebral type, as we call it, usually begins with back-leg ache. We use this expression as Hunter[7] writes that this sickness seems to be very frequent in China and goes under the name of back-leg ache. This fact brings the disease to the attention of the orthopaedic surgeon and in our experience there is hardly a case that is not first diagnosed lumbago, sciatica, or, if the attending physician has orthopaedic inclinations, the diagnosis may be more refined,—sacro-iliac or intervertebral arthritis, disturbance of the nucleus pulposus in the intervertebral discs, and so forth. As the disease progresses, the pain increases and the x-ray shows the apparent kyphosis manifested by wedging of the vertebrae, loss of lime in the vertebrae, and pathological fractures of the vertebral bodies. The first two of our cases at this stage of the affection, when they needed codein and morphin for their pain, were diagnosed metastatic malignancy,—the first one of unknown origin, the second as malignant myeloma. To be sure, the differential diagnosis of metastatic malignancy at times is quite difficult, especially in cases of prostatic carcinoma if the primary cancer is not evident; but one ought to become suspicious that there is no malignancy if the patient lives one, two, or three years without coming to the customary ending of metastatic malignancy. This was really the only reason that in our first two cases the diagnosis was finally changed, and the patients were given relief by the removal of parathyroid tumors (See Figures 1, 2, and 3).

In three other cases of the vertebral type a diagnosis of fracture was

FIG. 6

E. P., fourteen years old. Juvenile form. Note extreme deformities and scars of bed sores showing how sick this girl was from her hypercalcaemia, multiple fractures, and osteomalacic process.*

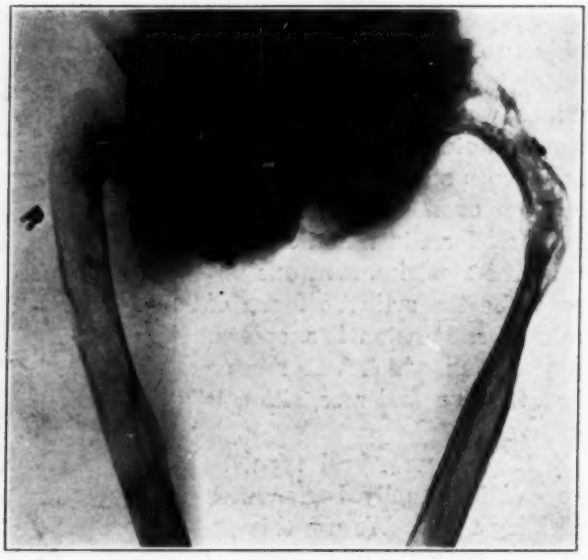

FIG. 7

Shows roentgenogram of same patient before removal of parathyroid adenoma. Great decalcification of pelvic bones and cysts in both femora. Pathological fractures through left upper femur. This type of femur is rather characteristic of the juvenile type with coxa vara.

made; one patient was placed in a plaster-of-Paris corset, another was advised that he should have a bone graft or some other stabilizing operation to support the broken vertebra. These details are given for the sake of bringing out the importance of proper diagnosis. One of these patients had in childhood, ten years previous to the slight accident that led to the compression fracture of the vertebrae, an operation on the neck of the femur, some mass being removed without getting a good diagnosis; in the light of our present knowledge, no doubt this was some cystic mass. These findings should have called attention to the fact that there must be a general skeletal disease that caused the disease in the femur and the fracture. In a second case the fracture happened from such a minute cause that, without malignancy being present, there should have been enough reason to go over the whole skeleton for a general affection. When these two cases came under our care, each had extensive lesions in the spine, skull, and other bones, high serum calcium, low serum phosphorus, pronounced hypotonia of the muscles as shown in muscle tests and electrocardiogram; so that the diagnosis could not be doubted. The lesson to be gained from this is that any compression fracture of the spine acquired without undue violence should, in our day, be an indication for studying the blood chemistry and taking a general roentgenological survey

* Case illustrated in Figures 6, 7, and 8 was operated upon by Dr. Grover C. Penberthy of Harper Hospital.

FIG. 8

Roentgenogram of same patient after parathyroidectomy. Note recalcification of pelvic bones, return of outline of all bones shown, and recalcification of the subtrochanteric fracture.

of the skeleton, especially of the whole spine and skull. The skull shows the changes very early (Fig. 4).

There is another type of older person who gets shorter and bends over; such patients are usually placed in the group of senile spondylarthritis or senile kyphosis, but their pain is so excruciating and their muscular weakness becomes so prominent that they become bedridden invalids. In this group the same diagnostic survey as to blood chemistry and skeleton should be made. We have operated upon at least six patients between the ages of sixty and seventy years, who were bedridden and needed opiates for their pain, and brought them back to a livable existence without pain. We should not call conditions senile and be satisfied with this diagnosis; if the majority of human beings do not have such symptoms of senility, it is logical that there must be some other special reason for this suffering besides age. A parathyroidectomy is not a dangerous operation; in the future it will be still less so and is worth considering if it can make the evening of a life free from pain (Fig. 5).

2. Much more difficult is the question of the infantile skeletal lesions and their connection with parathyroidism. There is one group which usually develops very rapidly, begins with general intestinal and urinary symptoms, followed quickly by skeletal pains and deformities. The x-ray shows general decalcification, cyst formations, and osteoclasias

FIG. 9

E. B. Smaller child of the same type as Fig. 6, five years old. Same coxa vara. Note shortening of right femur.

FIG. 10

Same patient. Subtrochanteric fracture of left thigh, causing great shortening of left leg.

FIG. 11

Lower legs of same patient. Note curving of the bones.

(Giant-cell tumors is the report if they are biopsied); multiple fractures occur, such as have been described by Hunter [8], Quick and Hunsberger [9], and others. These cases should be operated upon early to avoid the frightful deformities which later can only be arrested but perhaps not overcome by orthopaedic care following parathyroidectomy. Three such cases have been exarticulated in the hip joint, presumably for osteosarcoma (Beck[10]); in the last one, described by Gordon-Taylor and Wiles [11], a similar tumor developed in the other leg; cure followed removal of a parathyroid tumor. The author very candidly states that when the leg was amputated he did not know of the entity of parathyroidism. Surely, if three courageous men have reported such mishappenings, it is a logical conclusion that it has happened much oftener without being reported. The possibility of parathyroidism is also a reason for biopsy before amputation, in spite of warnings from eminent pathologists. A malignant osteosarcoma that is fatal anyway will not do much more harm if biopsied, and the protection of the patient against amputation of a limb should logically be the deciding factor for biopsy of such tumors.

Quick and Hunsberger's case, a young adolescent who shrunk from four to five inches with the most grotesque deformities of all his limbs, was first reported as multiple giant-cell sarcoma until the right diagnosis and parathyroidectomy led to the beginning of his cure. This case is mentioned to bring out the fact that giant-cell sarcoma is not a neoplasm, but a reaction of osseous tissue to certain factors, in this case decalcification, and is curable by parathyroidectomy.

FIG. 12

B. N. Child, now twelve years old, suffering from what was diagnosed as enchondroma for eight years. Note again the typical shortening of one leg in these juvenile forms, called by Shallow "arrested type".

At present we have under our care a young boy, fourteen years old, who has a little slower type of the disease, but with wide-spread cystic degeneration of the bones and three fractures so far. We have no doubt that parathyroidectomy will provide recalcification and union of the last fracture which has not yet shown any callus formation after several weeks. His roentgenograms are so striking that one is given here (Fig. 19*). Another case seen in consultation with Dr. Grover C. Penberthy is of the same group (Figs. 6, 7 and 8).

In smaller children the many different names given to the seemingly local symptoms of a general process are very misleading and probably need a check-up and a new nomenclature. We have five cases of undoubted parathyroidism, as proven by the blood chemistry and the roentgenograms, in which cystic processes developed around the upper end of the femora, leading to fractures—subtro-

* For a special reason explained in the legend, this figure is given last.

FIG. 13

Shows multiple fractures in tibia. Last fracture occurred at age of eleven years.

FIG. 14

Shows deformity of the femur and tibia.

chanteric usually—and extreme coxa vara, caused by the weight of the body on the decalcified necks of the femora, and in which one leg grew much shorter than the other (three to four inches difference); also three cases in which one arm became shortened for the same reason. If the fibrocystic process encroaches on the epiphyseal lines, it is easy to understand that we find in the bones cysts, besides giant cells, chondromatous tissue arising from the epiphyseal cartilage; and, therefore, a good many of them are diagnosed chondromata. Slipping epiphysis is another name used for the disturbance (See Figures 9–15). The results of parathyroidectomy in four of these cases, while most of them have only been observed for a short time (one, however, for more than sixteen months), are so encouraging that parathyroidectomy may be recommended early.

FIG. 15

Skull of same case again gives proof of the general nature of the decalcification by granular mottling, etc.

FIG. 16

Mr. T. Shows the spine, rather resembling osteitis fibrosa cystica with its compressed vertebrae. (See Fig. 17.)

FIG. 17

Mr. T. Typical Paget's skull with great thickening. Hard of hearing. Head size increased two full sizes. Stature shrunk three inches. Severe pain and asthenia.

FIG. 18

Same skull as Fig. 17 six months after removal of two parathyroids. Note the much clearer outline of the parieto-occipital region, fuzziness of the outer table disappearing, hearing improved. Stature is erect again, has regained one and one-quarter inches in height, and can walk several miles without discomfort. Before operation 100 yards would tire him out.

Moreau[12] maintains that all the conditions showing decalcification and disturbed calcium metabolism as main symptoms are controlled by endocrine disturbance, chiefly of the parathyroid. Many orthopaedic men have emphasized this fact in discussing the different forms of epiphysitis and arthritis (Kidner[13] and Pemberton[14]). Moreau, however, goes further in claiming that "it does not make much difference whether repeated trauma or a microbic agent is a contributing factor, the pathogenetic endocrine factor is the important one; without this the injury or the mild infection would not produce the peculiar phenomena of the faulty calcium distribution and this may be local or general". Moreau also mentions that "under this 'intriguing hypothesis', besides the osteopoicilia and marble bones, would come many similar conditions,—melorheostosis (Leri, 'candle-drip' hyperostosis of bones), Paget's disease, hypophyseal dysostosis or Schüller-Christian syndrome, leontiasis ossea, hyperostotic lumbarthria, calcification of the nucleus pulposus, Kümmell's disease, Sicard's disease, Putti's disease, etc., etc.". It is pleasing that in our work on these conditions, Paget's disease, leontiasis ossea, and the calcifications in the nucleus pulposus have already been included in the group of parathyroidism (Ballin and Morse).[15] To be sure, it will require observation for a few years more, especially on the results of parathyroidectomy in these children, to ascertain what really belongs to parathyroidism. The clinical

FIG. 19

G. P., boy, fourteen years old, with multiple fractures at the age of three. Multiple osteoclastomata in practically all bones of hands, toes, etc. This roentgenogram is shown on account of the simultaneous existence of osteopoicilia and osteitis fibrosa cystica at arrow. Osteopoicilia and marble bones have been considered by some to be of parathyroid origin, which this picture perhaps confirms.

test as to whether these little patients can be benefited by parathyroidectomy will be the final deciding factor.

3. The arthritic form which Dr. Robert Funsten has discussed (See page 112) should receive careful attention. Parathyroidism has its distinctive place as to origin and so forth in a selected group of arthritis cases.

4. A few words about Paget's disease. I will not go into the long-standing dispute as to whether osteitis fibrosa cystica (von Recklinghausen) and osteitis deformans (Paget) are two different entities or not. Pathologically, microscopically, and clinically we find transitory stages from one to the other. The incidence of sarcoma in Paget's disease is also not a distinguishing factor. But now the results of parathyroidectomies in Paget's disease confirm the opinion that the two diseases are identical and can be controlled by parathyroidectomy. We have published elsewhere the results of Shouten[16], Boevé[17], Chifoliau, Léri and Weill[18], Sainton, and others in cases where the symptoms were mixed in the same patient; these patients usually had Paget skulls or femora and osteitis fibrosa cystica in arms and spines. Both types of symptoms improved after parathyroidectomy. Of the true Paget type we have operated on three cases,—one, seemingly, a monostatic Paget's disease of the femur in which, however, a general survey of the skeleton by roentgen ray showed other decalcifying lesions; the second and third typical Paget's disease with thickened skulls and so forth, in which parathyroidectomy showed immediate improvement as to pain, the hyperostotic fuzzy outline of the skull disappearing and a clearer outline of the external table becoming apparent. In the first of these cases the indistinct, thickened outline of the femur, within two months after the operation, showed a clear outline of the marrow cavity and the cortical substance (Figs. 16, 17, and 18). The French, who have given a good deal of consideration to this question of Paget's disease, have come to the conclusion that one should explore the parathyroid region to ascertain as to whether the case is a Recklinghausen's disease or a Paget's disease (Sainton[19]).

5. A few cases of parathyroidism will express themselves mainly in gastro-intestinal symptoms (Pemberton and Geddie[20]); in others the muscular weakness is outstanding. The weakness of the movements of these patients resembles a pseudohypertrophy of the muscles. Frequent falls occur on account of the hypotonia, the legs giving way. Often such patients come to the orthopaedic surgeon for severe backache. In most of these cases a thorough study of the muscular reaction and of the blood chemistry will lead to the right diagnosis and some splendid cures have been effected by parathyroidectomy. Four methods are in vogue for diagnosing the muscular hypotonia:

a. The determination of the milliamperes needed to provoke the muscular contraction (Oppel[21]).

b. The finer method of determination of chronaxia,—that is, bringing in the time factor of the muscular contraction (Bourguignon[22]).

c. The moving picture will show the slow and weak action of the muscles (Rowntree [23]) and allow comparison preoperatively and postoperatively.

d. The electrocardiogram shows that the muscular weakness does not spare even the heart muscle, this being proven by the shortening of the R. T. interval.

It is not possible here to go into the details of these methods which have been described elsewhere (Edward D. Spalding [24], Ballin and Morse).

In a few cases the muscular atony is accompanied by coldness and bluish color of the limbs and this has led to ganglionectomies for suspected Raynaud's disease. Pressure on cranial nerves by the softened and deformed Paget skull, or on the spinal root and the cord in the case of osteitis fibrosa cystica of the spine, has led to diagnoses of cerebral affections or spinal tumors. We know of three such cases where a parathyroidectomy should have been done instead of ganglionectomy or laminectomy. Sainton calls all the forms mentioned under this last section "*formes frustes*" of parathyroidism.

A few conclusions of our studies are:

1. The knowledge acquired in the study of parathyroidism makes it necessary for physician and surgeon to pay much more attention to blood chemistry as far as calcium and phosphorus are concerned, and not to limit roentgen-ray examinations to one painful spot if there is even a suspicion of a general skeletal affection. Intractable back-leg aches, curving of the spine, shortening of the stature, multiple fractures, pathological fractures not explained by metastatic malignancy, bone cysts, giant-cell tumors,—all should demand the study of the patient for the presence of parathyroidism.

2. While osteitis fibrosa cystica is the main skeletal affection caused by parathyroidism, Paget's disease and certain forms of arthritis with some calcium disturbance, muscular hypotonia, indigestion with vomiting, dysuria with high serum calcium,—all should be studied carefully as to the parathyroid factor.

3. Besides the parathyroid, the thyroid, Cushing's syndrome in certain adenomata of the anterior lobe of the pituitary gland, and other rarer endocrine disorders may show skeletal disturbances, but probably a parathyroid factor is present in all these types.

4. As to treatment, a trial with the well known therapy for rickets and osteomalacia—sunlight, ultraviolet rays, irradiated cod-liver oil, and calcium preparations—is worth while; transitory forms from rickets with only compensatory hyperplasia of the parathyroids to real parathyroidism, also mild types of the latter may yield to such treatment. Rapidly progressive cases of parathyroidism and exacerbations after temporary remissions should be operated upon before permanent deformities of the skeleton or serious damage, especially to the kidneys, supervene.

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NOTE: Much of the important information presented at the Annual Meeting of the American Orthopaedic Association at Toronto in the discussion of the subject of parathyroidism has been incorporated in the following papers by Dr. Bauer, Dr. Compere, and Dr. Nachlas. These observers, who have been interested in laboratory studies and investigation of this subject, are presenting in their communications some of the results of their work in this field.—*Editor.*

HYPERPARATHYROIDISM: A DISTINCT DISEASE ENTITY *†

BY WALTER BAUER, M.D., BOSTON, MASSACHUSETTS

An adequate description of a previously unrecognized disease is frequently necessary in order to establish the fact that it is not a rarity. Such has been our experience with the disease called hyperparathyroidism or generalized osteitis fibrosa cystica (von Recklinghausen[1]), as shown by the large number of cases reported during the six years that have elapsed since the first cases were recognized clinically[2, 3]. If sufficient interest is aroused concerning this disease, perhaps more of the earlier cases will be detected and parathyroidectomy performed before the permanent bone changes and complications have occurred. But what is of even more interest at this time is whether or not other skeletal diseases are due to hyperparathyroidism. Certain workers[4, 5, 6, 7, 8, 9, 10, 11, 12, 13] have suggested that other skeletal diseases,—namely, certain cases of arthritis and Paget's disease—are due to hyperparathyroidism. If such skeletal diseases are due to hyperparathyroidism, then the cause and the cure of two previously obscure diseases have been discovered. Personally, I do not believe we have sufficient data to prove that either of these diseases is due to an increased secretion of the parathyroid hormone. Therefore, I do not think we are justified in advising parathyroidectomy in other than proven cases of generalized osteitis fibrosa cystica. My reasons for making these statements are:

Hyperparathyroidism or generalized osteitis fibrosa cystica is a clear-cut, distinct disease entity caused by an increased secretion of the parathyroid hormone. This disease was first recognized clinically by Mandl[2] in Vienna and by DuBois[3] in America. All cases thus far reported have been due to a parathyroid adenoma. The fact that it is a disease of endocrine origin implies that the entire skeleton is affected. Arthritis and Paget's disease are never generalized skeletal diseases. This fact alone argues against their being of parathyroid origin. Hyperparathyroidism is a disease characterized by definite alterations in the calcium and phosphorus metabolism as well as by certain symptoms and signs. The alterations in the calcium and phosphorus metabolism are:

* From the Medical Clinic of the Massachusetts General Hospital.

† This is publication Number 11 of the Robert W. Lovett Memorial for the study of crippling disease, Harvard Medical School, Boston, Massachusetts.

1. *An Elevated Serum Calcium.* Serum calcium values as high as twenty-three and six-tenths milligrams per 100 cubic centimeters have been reported[14]. The normal serum calcium varies between nine and five-tenths and ten and five-tenths milligrams.
2. *A Decreased Serum Phosphorus.* Values as low as one and four-tenths milligrams per 100 cubic centimeters have been observed[3], in contrast to normal values of four to five milligrams.
3. *An Increased Calcium Excretion.* The increased excretion of calcium is entirely urinary, the fecal excretion being unaffected.
4. *An Increased Phosphorus Excretion.* The increased excretion of phosphorus is also entirely urinary.

   The increased excretions of calcium and phosphorus in one reported case were of the same magnitude as those in a normal individual receiving 100 units of an active parathyroid extract per day[3].

These alterations in the calcium and phosphorus metabolism may be accompanied by any or all of the following symptoms and signs:

1. Polydipsia.
2. Polyuria.
3. Weakness and loss of strength.
4. Constipation.
5. Loss of appetite.
6. Loss of weight.
7. Indefinite muscle and joint aches and pains (commonly diagnosed rheumatism, arthritis, or neuritis).
8. Bone tenderness.
9. Frequent fractures, often following slight trauma.
10. Decreased excitability of the nerves.
11. Skeletal shortening.
12. Kyphosis.
13. Bone tumors, frequently diagnosed epulis of the jaw or giant-cell tumor in other bones.
14. Kidney or ureteral stones (usually bilateral).
15. Characteristic x-ray findings,—such as, generalized decalcification, bone tumors, multiple bone cysts, fish-type vertebral bodies, etc.
16. Frequently anaemia with leukopenia.

In view of the above facts, I do not believe any patient should be subjected to a parathyroidectomy until sufficient evidence has been gathered from the history, physical examination, roentgen examination and metabolism studies to leave no doubt as to the correctness of the diagnosis of hyperparathyroidism. Until some simple test for hyperparathyroidism is devised, all suspected or questionable cases of hyperparathyroidism should be very carefully studied. Serum calcium and serum phosphorus determinations should be made and, if possible, serum phosphatase as

well as total calcium and phosphorus metabolism studies. It certainly behooves us all to proceed cautiously before making or accepting any statement which implies that certain cases of arthritis are due to hyperparathyroidism or that Paget's disease is of parathyroid origin.

Oppel[5] first reported favorable results in cases of spondylitis deformans (Strümpell-Marie type) following parathyroidectomy. Later Leriche[4, 8] and others[6, 7, 9] reported similar results in cases of ankylosing polyarthritis. Funsten[10] stated that certain of his cases had been operated upon by Dr. Ballin with very gratifying results. The arguments which have been advanced that certain cases of arthritis are due to hyperparathyroidism are: (1) that some of these cases have a definitely increased serum calcium, and (2) that the ankylosis observed is a manifestation of the disease. No one of these observers present metabolism studies showing that the previously mentioned alterations in the calcium and phosphorus metabolism were present, nor do they present sufficient data pertaining to the history, physical examination, or roentgen examinations to enable one to make such a diagnosis. One must further remember that metastatic calcification is a very late manifestation of the disease and occurs only in fatal cases or in animals which have succumbed to overdoses of parathormone.

Dr. Funsten stated that in suspected cases one should do repeated serum calcium determinations. By doing so, one will obtain one or two serum calcium values which are distinctly elevated, thus enabling one to make a diagnosis of hyperparathyroidism. All cases of hyperparathyroidism, which we have observed, have had a permanently elevated serum calcium and not transitory elevations such as reported by Dr. Funsten. We usually ascribe transitory elevations in serum calcium as due to a failure to obtain a fasting blood sample, and, if this has not been the case, we always raise the question of whether or not there has been any error in technique. It must be remembered that a serum calcium determination tells one only the height of the calcium stream and not its direction of flow into the bones or into the excretory channels. If one realizes this fact, he can understand the need of doing total calcium and phosphorus metabolism studies in any suspected or questionable case.

I, personally, have never seen any findings in patients with either form of arthritis that would suggest the existence of hyperparathyroidism as a causal factor. True, many of the cases of rheumatoid arthritis show x-ray evidence of decalcification (bone atrophy). However, this is no more than we often see associated with disuse. Furthermore, we know that the calcium excretion of a patient when immobilized in a cast is much higher than when this same patient is allowed ordinary ward activity. To date, we have studied the total calcium and phosphorus metabolism of a series of cases, some of them having rheumatoid or proliferative arthritis, others having hypertrophic or degenerative arthritis. We took particular pains to see that we had chosen cases of rheumatoid or proliferative arthritis that showed marked bone atrophy and cases of degenerative

or hypertrophic arthritis showing marked proliferative bone changes. As a result of these studies, we can state that we found no changes in the serum calcium or serum phosphorus or the calcium and phosphorus metabolism of a degree sufficient to enable one to make a diagnosis of hyperparathyroidism. The alterations in the calcium and phosphorus metabolism observed were hardly any more marked than one obtains in a study of a large series of normal individuals observed on the same régime.

The improvement reported in cases following parathyroidectomy may have been due to anaesthesia, rest in bed, or a natural remission of the disease. These three factors are all capable of bringing about improvement, particularly in cases of rheumatoid arthritis. Because the latter disease is characterized by remissions and relapses, improvement is often ascribed to a particular form of therapy, whereas in reality it may represent nothing more than a natural remission.

Another reason why I am skeptical about arthritis occurring as a result of hyperparathyroidism is the fact that in the last five years at the Massachusetts General Hospital the two diseases have never been observed in the same patient, although seven cases of hyperparathyroidism have been studied.* All seven cases have satisfied all the requirements necessary to make such a diagnosis; all cases have been operated upon and in each instance a parathyroid tumor was found; yet no one of them had arthritis.

One patient has been known to have had the disease for thirteen years. This patient, a sea captain, was first recognized as a case of hyperparathyroidism by Dr. Eugene F. DuBois in 1926[3]. He has suffered from eight fractures. He has a marked kyphosis, considerable skeletal shortening, and permanent bone deformities. His serum calcium has ranged between thirteen and one-tenth and sixteen and five-tenths milligrams per 100 cubic centimeters as compared to normal values of nine and five-tenths to ten and five-tenths milligrams. The serum phosphorus varied from one and four-tenths to three and two-tenths milligrams per 100 cubic centimeters. The calcium and phosphorus excretions were markedly elevated. He was operated upon by Dr. E. P. Richardson [15] in May, 1926, and June, 1926. At each operation a parathyroid gland was removed, normal in appearance, but microscopic examination showed fatty infiltration. Removal of these two glands did not result in a cure, and the serum calcium and phosphorus, as well as the total calcium and phosphorus metabolism studies, remained unchanged. Despite a high calcium diet his symptoms and signs increased to such an extent that a third search was made for a parathyroid tumor in March, 1932, by Dr. Russel H. Patterson of New York City, but again no tumor was found. He was again transferred to the Massachusetts General Hospital in May, 1932. Examination at this time showed considerable increase in the severity of his disease. The decalcification had increased; there were

* Six of these cases were thoroughly studied by Dr. Fuller Albright. Detailed reports concerning these cases will be published by him in the near future. I am indebted to Dr. Albright for having seen these patients.

many more bone cysts; questionable calcification of the kidney cortex, demonstrable on flat x-ray plate of the abdomen; kidney and ureteral stones; hypercalcaemia and hypophosphataemia. Kidney function tests showed marked renal impairment evidenced by a non-protein nitrogen of sixty milligrams per 100 cubic centimeters and a phensulphophthalein excretion of ten per cent. in two hours' time. At three subsequent operations by Dr. Oliver Cope and Dr. E. D. Churchill, careful dissections of the various regions of the neck between the angles of the jaw and upper mediastinum were made; yet no parathyroid tumor or tissue was found. On November 2, 1932, an anterior mediastinotomy was done by Dr. E. D. Churchill. The parathyroid tumor, encased in a calcified capsule, was found; ninety per cent. of it was excised, the remainder of the tumor was turned up on its pedicle and sewed in a superficial position in the region of the sternal notch. The serum calcium fell rapidly, and signs of tetany appeared on the third day. At this writing the serum calcium continues to fluctuate between four and five-tenths and seven and two-tenths milligrams.

Therefore, this patient not only had the disease for thirteen years, but also suffered from permanent bone deformities and the complications of hyperparathyroidism; yet there was no evidence of arthritis.

Ballin [11] and Ballin and Morse [12, 13] have stated that Paget's disease is likewise due to hyperparathyroidism. I cannot agree with this statement, as the signs and symptoms of the two diseases are not the same. There are many differences when one compares Paget's disease with hyperparathyroidism. Many of the differences were stressed by the late Prof. Schmorl [16] in an exhaustive pathological study of the largest group of cases of Paget's disease ever reported. Paget's disease occurs in older people, usually males, and is regularly associated with marked arteriosclerosis, whereas hyperparathyroidism is met with in all age groups, more commonly in females, and arteriosclerosis is not a common finding. Malignant bone tumors develop in a fair number of the cases of Paget's disease; such is rarely, if ever, observed in hyperparathyroidism. Fractures (frequently spontaneous) occur very often in hyperparathyroidism and seldom in Paget's disease. Renal calculi are the exception in Paget's disease but are very often found in hyperparathyroidism. In Paget's disease, the changes are sometimes confined to one lone bone and, as Schmorl points out, the entire skeletal system is never involved. However, in hyperparathyroidism, a disease of endocrine origin, the effect is a generalized one, every bone of the body being involved. Although gross examination does not always reveal the generalized nature of the disease, microscopic examination does. The bones in Paget's disease are soft, often bowed, and a thickened cortex is demonstrable on both x-ray and macroscopic examination. In hyperparathyroidism, x-ray examination shows bones with thinned cortices and bone cysts. In the gross, one observes thinning of the cortices, bone cysts, and the brown tumors described by von Recklinghausen. It is true that histological bone sections

from these two diseases may be similar and therefore it may be difficult to make a diagnosis on this basis alone, even though the histological features of these two diseases are usually characteristic.

Turning to the calcium and phosphorus metabolism studies, one finds very little to support the theory that Paget's disease is due to hyperparathyroidism. A high serum phosphatase is present in both, but is much more marked in Paget's disease. However, it should be remembered that an elevation in serum phosphatase occurs in other bone conditions. In collaboration with Doctors Aub, Albright, and Marble[17] the author has studied the calcium and phosphorus metabolism in seven cases of Paget's disease. These patients represented the early and late stages of the disease. They also represented various ages. No one of this series or other cases (on whom no metabolism studies were carried out) showed any elevation of the serum calcium or lowering of the serum phosphorus. In two of the cases thoroughly studied, the calcium and phosphorus excretions were slightly increased, but the increased excretions were not confined solely to the urine as they are in cases of hyperparathyroidism.

Because of his inability to demonstrate the presence of parathyroid tumors in his large series of cases, Schmorl concluded that Paget's disease was not due to hyperparathyroidism. He found no more enlargement of the parathyroid glands in Paget's disease than under normal conditions. In discussing its etiology, he presents certain evidence that the observed pathology might best be explained on a vascular basis. He further suggests that stress and strain may well play a rôle in bringing about the bone changes. In support of this theory he shows that the bones subjected to the most stress and strain are most frequently involved.

Ballin and Morse believe that the improvement observed following parathyroidectomy supports their theory that the disease is of parathyroid origin. Their cases had not been followed for a sufficiently long period of time to state definitely that lasting benefit or a cure had been obtained. The operation and rest in bed may have been responsible for the improvement reported. The author has observed patients who reported considerable improvement when made to adhere to a high calcium, high vitamin diet and regular rest periods. Furthermore, in the natural course of Paget's disease there may be periods during which the patient may complain of very few symptoms.

Until we have sufficient evidence to prove that Paget's disease and certain cases of arthritis are due to hyperparathyroidism, I believe there is no justification in advising parathyroidectomy in patients with either disease.

CONCLUSIONS

1. Hyperparathyroidism, a generalized skeletal disease, is a distinct disease entity due to a parathyroid adenoma. It is characterized by definite alterations in the calcium and phosphorus metabolism, symptoms, and signs. These findings have been presented as concisely as possible.

2. Data have been presented showing that arthritis is not associated with or due to hyperparathyroidism.

3. Paget's disease is not a generalized skeletal disease as is generalized osteitis fibrosa cystica. This fact, as well as certain clinical and metabolic data, clearly demonstrates that Paget's disease is not due to hyperparathyroidism.

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THE RÔLE OF THE PARATHYROID GLANDS IN DISEASES ASSOCIATED WITH DEMINERALIZATION OF THE HUMAN SKELETON *

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Hyperparathyroidism, usually associated with an adenomatous tumor of one or more of the parathyroid glands, has been established as the etiological factor in the production of generalized osteitis fibrosa, a very chronic disease which progresses with pain, fractures, and disabling deformities, and may be fatal. There is generalized demineralization of the bones of the skeleton, and multiple foci of osteitis fibrosa, with or without benign giant-celled tumors, and cysts are common. It is a disease entity different from local osteitis fibrosa, osteitis deformans, osteogenesis imperfecta, osteomalacia, rickets, and ankylosing polyarthritis. The similarity between the roentgen-ray studies of some of the conditions in this group is well known, and the most experienced pathologist may at times find it difficult to differentiate between the gross or microscopic picture of bone affected by von Recklinghausen's disease and a section of bone from a case of Paget's disease. The clinical picture of several of the abnormal skeletal conditions mentioned may be very similar to that of generalized osteitis fibrosa (von Recklinghausen's disease). But while clinically, roentgenologically, and pathologically similar, there is a difference in the biochemical manifestations of these diseases as demonstrated in studies of the mineral metabolism.

The mere recognition of osteoporosis of the human skeleton associated with hypotonia and decreased irritability of the muscles to electrical stimuli, with or without an elevation of the serum calcium, is too little evidence upon which to base a diagnosis of overfunction of the parathyroid glands. The presence of enlarged parathyroid glands, in the absence of a negative calcium balance, or at least a reduced calcium balance, is not sufficient evidence to justify their removal. Hyperplasia of the parathyroid glands may be a purely compensatory enlargement in response to a demand of the organism as a result of a deficiency of calcium absorption from the bowel. This has been demonstrated clinically in cases of deficiency diseases, such as osteomalacia and rickets, by Hoffheinz[1] and Erdheim[2] and in studies of experimentally produced rickets by Pappenheimer and Minor[3], Doyle[4], Nonidez and Goodale[5], Higgins, Foster and Sheard[6], Erdheim[7], and Luce[8]. Some of the parathyroid glands became ten times as large as normal and the microscopic sections revealed benign hyperplasia similar to that described by Ballin and Morse[9] in enlarged glands removed from patients suffering from ankylosing polyarthritis. Treatment of the rickets with diet and

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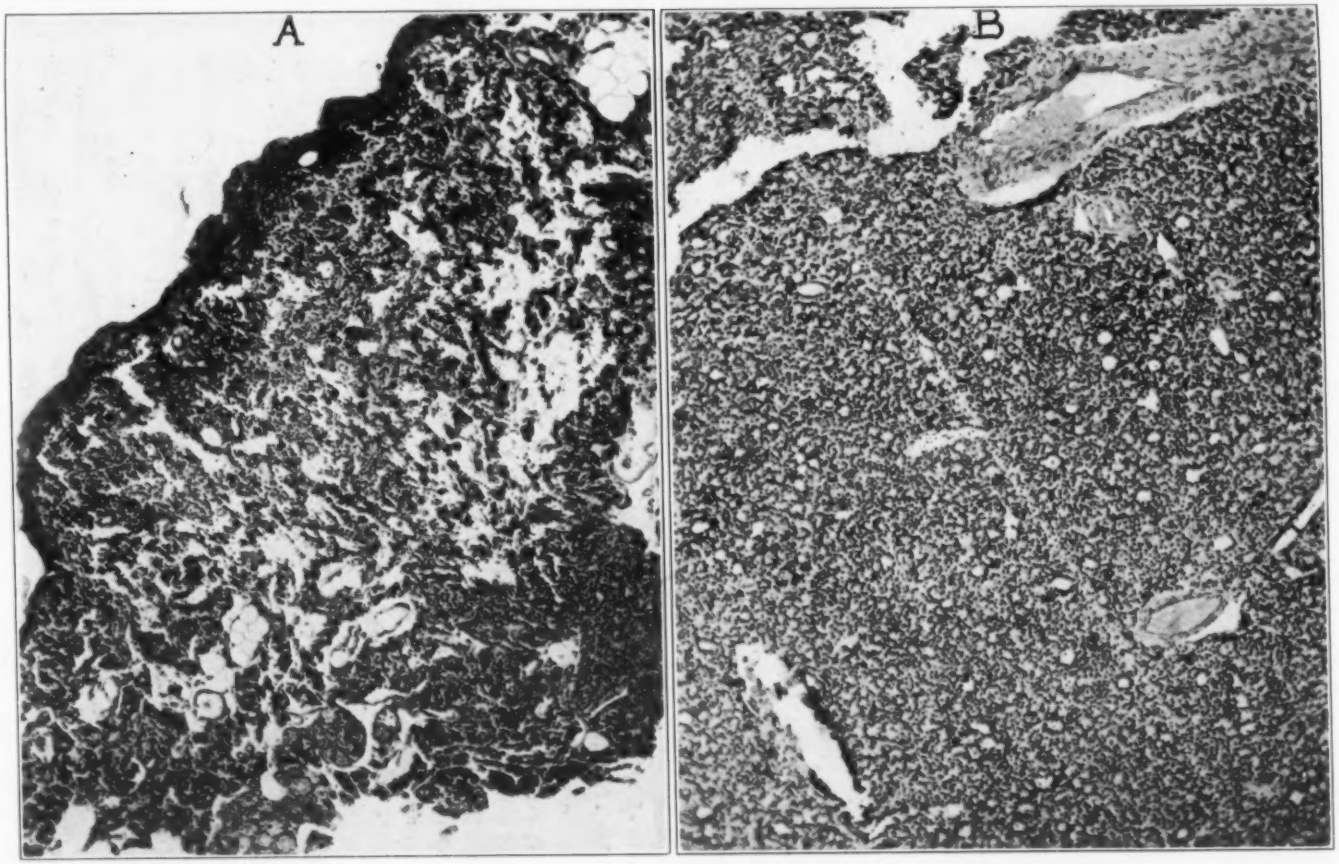

FIG. 1

A. Normal parathyroid gland cell structure and arrangement similar to that of enlarged glands removed from patients with ankylosing polyarthritis. × 70.

B. Adenoma of parathyroid gland typical of the tumors found in cases of von Recklinghausen's generalized osteitis fibrosa. See Table II for comparison of microscopic pictures. × 70.

TABLE I

MICROPATHOLOGY OF THE PARATHYROID GLANDS

Normal Gland or Benign Hyperplasia, Typical of Those Reported in Rickets, Osteomalacia, Metastatic Osteoplastic Carcinoma, and Ankylosing Polyarthritis.	*Adenoma of the Parathyroid Gland Typical of That Reported in More Than Forty Cases of Generalized Osteitis Fibrosa Cystica of von Recklinghausen.*
Cellular elements may be diffuse or compact	Cellular elements very compact
Definite arrangement of irregular strands or trabeculae	Less connective tissue and no strand-like arrangement of cells
Occasional acinus	Numerous acini
Many fat cells	Few or no fat cells
Many foam cells	No foam cells
Few granules in nuclei	Large dark-staining granules in nuclei of cells

vitamin D resulted in decrease in the size of the parathyroid tumors. Since these tumors were produced on a deficiency diet and were found to recede when the deficiency was corrected, the hyperplasia in this condition was obviously compensatory (Fig. 1 and Table I).

Oppel[10], Ssamarin[11], Leriche and Jung[12], Ballin[13] and Funsten[14], have reported clinical improvement in cases of ankylosing polyarthritis following parathyroidectomy. A review of the description of the microscopic studies as well as of the photomicrographs published has failed to demonstrate a true adenoma of one or more of the parathyroid glands in these series. Enlargements of the glands in some cases were reported, but the cell picture was that of simple hyperplasia. Those who have reported these studies have accepted the clinical syndrome of generalized demineralization of bones, hypotonia of the muscles, and lengthening of the chronaxia with an increase in the serum calcium, as sufficient evidence to make a diagnosis of "parathyroidism". Ballin and Morse also state that "hypercalcaemia can be temporarily or continuously absent, and if so should not exclude the diagnosis of parathyroidism if all other symptoms speak for it". The most definite and pathognomonic finding in true hyperparathyroidism due to an adenomatous tumor is that of a negative calcium balance, but Bauer[16] and his associates have found that every case of ankylosing polyarthritis in their series was in positive calcium balance. No reports are published by the authors who advocate parathyroidectomy in ankylosing polyarthritis to show their results in studies of metabolism of calcium and phosphorus.

Leriche and Jung reported the serum calcium slightly elevated in only three of twenty cases of ankylosing polyarthritis which they studied. Parathyroidectomy was attempted in each of these cases. Marked symptomatic improvement was reported for the first case, but six months after the operation the patient had suffered a relapse and was worse than

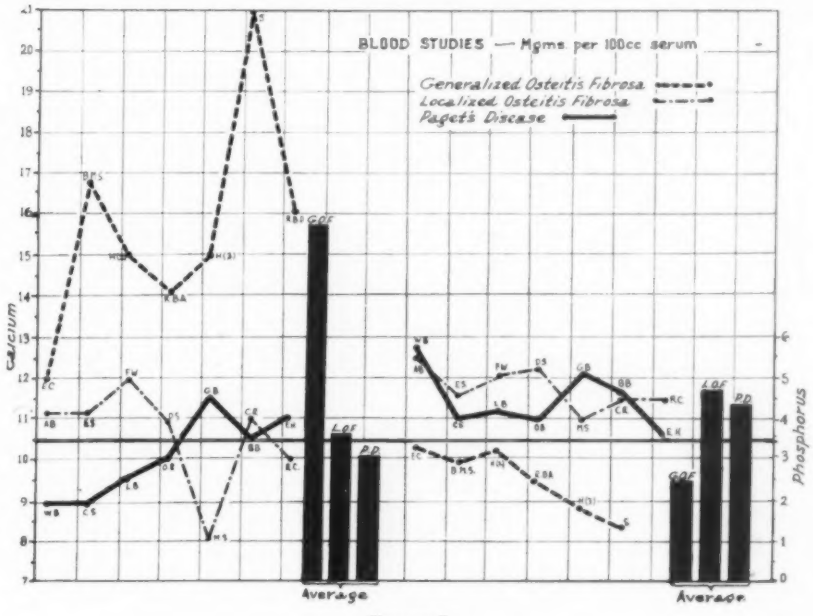

CHART I

The striking contrast between the calcium and phosphorus content of the blood serum in true hyperparathyroidism due to a parathyroid adenoma and osteitis deformans (Paget's disease) is well illustrated in this graph. The average of the blood serum calcium in seven cases of generalized osteitis fibrosa (G.O.F.) is almost twice that in seven cases of localized osteitis fibrosa (L.O.F.) or Paget's disease (P.D.), while the ratio of phosphorus in the serum in the three conditions is reversed.

at the time of the first admission. The authors at this time tried the injection of parathyroid extract intramuscularly in this patient and again reported improvement. In the second and third cases there was also improvement, but the pathologist was not able to find any parathyroid tissue in the specimen removed from the second case. Apparently the improvement here was just as marked as in the cases where the parathyroid tissue was definitely excised.

In a number of the cases studied by Ssamarin and operated upon by Oppel, no parathyroid tissue was found in the specimen removed. The fact that these patients showed improvement comparable to the cases from which the glands were removed indicates that some other factor must have accounted for this change. Welti[15] and Bauer[16] agree with us that there is not sufficient evidence to show that in any case of ankylosing arthritis there was also a true hyperparathyroidism, although some of the symptoms of this condition may be found. Furthermore, the fact that ankylosing polyarthritis was not noted in any of the more than fifty cases of generalized osteitis fibrosa which have been reported, in which very high serum calcium and low serum phosphorus were found and a parathyroid adenoma was removed at operation or postmortem examination, is certainly significant. Bodansky, Blair and Jaffe[17] and Johnson[18]

TABLE II

Differential Diagnosis of Conditions Characterized by Demineralization of the Bones

Disease	Osteoporosis	1. Cysts 2. Giant-cell tumor	Pathological Fractures	Muscles	Chronaxia	Pain	Characteristic Arthritic Changes	Serum		Urine	Balance	Sulphur Retention	Parathyroid Glands	
								Ca	P	Ca	Ca		Adenoma	Hyperplasia
										***	***	***	***	***
Osteitis fibrosa cystica, generalized (von Recklinghausen's disease)	Generalized	1. Common 2. Common	And compression of vertebral bodies, common.	Hypotonia	Lengthened	In spine or long bones of lower extremities	None	High	Low	*Increase*	—	+ balance	Tumor of one or two	Remaining usually normal in size and microscopic findings
Osteitis deformans (Paget's disease)	Hyperostosis	1. Yes 2. None	Less common	Hypotonia	Lengthened	In long bones or spine	None	Normal or below	Normal or above	*Decrease*	+	— balance (loss)	No definite or true adenoma reported in an accepted case of Paget's disease	All usually normal
Ankylosing polyarthritis	Generalized	1. None 2. None	Uncommon. Compression of vertebral bodies, common.	Hypotonia	Lengthened	In long bones or spine	Calcification of paravertebral ligaments with ankylosis of the joint	Occasionally above normal	Normal	Normal	+	+ balance	No true adenoma	All parathyroid glands may be enlarged, with normal cell structure. (Probably compensatory.)
Osteomalacia	Generalized	1. Common 2. Common	Occasional. Bending common.	Hypotonia (occasional tetany).	Shortened or normal in low Ca type	In long bones or spine	None	Low	Low	Normal or below	— (low Ca intake)	Not definitely established	Found in few instances of high Ca type	All glands frequently enlarged (reported at autopsy)
Rickets	Generalized	1. Occasional cyst-like areas	Occasional	Hypotonia. Tetany occurs rarely.	Shortened or normal in low Ca type	Not common	None	Low	Low	Low	+	Not constant	Very rare	Common (compensatory)
Osteogenesis imperfecta	Generalized	1. None 2. None	Very common	Hypotonia	Lengthened or normal	Not characteristic	None	Normal	Normal	Normal	+	Not reported	None	Reported in three cases
Osteitis fibrosa localized and regional	Normal bone density except in local or regional areas	1. Local, usually solitary	Common at site of lesion.	Normal	Normal	At site of lesion only	None	Normal	Normal	Normal	+	Normal	None	None reported

*** Findings which are of pathognomonic significance in the diagnosis of generalized osteitis fibrosa.

Table II. This comparison of the skeletal dystrophies which are characterized by demineralization of the bones reveals some points of similarity, but the most significant and diagnostic evidence of the presence of an adenomatous tumor of one or more of the parathyroid glands—namely, a high serum calcium accompanied by a low serum phosphorus, marked increase in output of calcium in the urine, *negative calcium balance*—and the gross and microscopic evidence of a true adenoma of one or more of the parathyroid glands are noted consistently only in cases of generalized osteitis fibrosa.

produced typical generalized osteitis fibrosa in experimental animals by injecting parathyroid extract, but none of these animals developed arthritis.

In Paget's disease the calcium metabolism as demonstrated in our own series and also by Hunter[19], Rabinowitch[20], Van Hazel and Andrews[21] and DaCosta, Funk, Bergeim and Hawk[22], is usually one of marked positive balance with a greatly diminished excretion of calcium by the kidneys. Improvement has been noted following administration of parathormone. Erdheim[23] found no tumors of the parathyroid glands removed at autopsy from patients with Paget's disease. Gold[24] reported the pathological studies of Maresch who made postmortem examinations of the parathyroid glands of forty cases of Paget's disease and was not successful in finding a parathyroid tumor in the entire series. Excision of parathyroid glands from patients who are afflicted with osteitis deformans may be as serious an error as thyroidectomy in cases of myxoedema. Zimmer[25] has reported cure of a case by injection of parathyroid extract.

A case of marked Paget's disease, of twenty years' standing, recently came to autopsy in this clinic and complete pathological studies were made. The parathyroid glands were entirely normal.

In Table II, I have attempted to compare several of the clinical syndromes which are characterized by local or general demineralization of the skeleton. There is some evidence that ankylosing polyarthritis may be a deficiency disease similar to rickets or osteomalacia. The typical micropathology of the enlarged parathyroid glands in all three conditions is that of simple hyperplasia and may be a compensatory change. The success of Fletcher[26] in treating multiple arthritis by means of diets, rich in vitamin and mineral content, lends support to this theory.

As I have previously shown[27], "there is little evidence to indicate—and it would be difficult to rationalize the finding if it were so reported—that localized bone lesions of the bone cyst and giant-cell tumor type, without any general skeletal involvement, could be explained on a metabolic basis". The secretions of the endocrine glands must be distributed to all parts of the body and any marked effect which they may exert upon the tissues should be manifested uniformly and not locally or regionally. Experience has demonstrated that these localized lesions will heal following local excision and curettage or roentgen-ray therapy, and this further discredits the theory of an endocrine etiology.

Chronaxia has been defined by Ballin[9] as "an electric time coefficient of neuromuscular excitability defined as a minimal time in which current must pass through a muscle or nerve in order to elicit a reaction". It is not a specific test for parathyroid hyperfunction. Most conditions associated with weakness and general physical debility may give a similar delayed response. Mere fatigue in a perfectly normal individual will greatly alter the chronaxia determinations.

Too much emphasis has been laid upon the elevation of serum calcium in certain of these conditions and the equally significant plasma inorganic

phosphate determinations have not been made. The only definite test for parathyroid gland hyperfunction, which is acceptable, is the calcium metabolism study and the demonstration of a negative calcium balance. With the corresponding patients studied on a maintenance diet with basal requirements of calcium and phosphorus and also vitamin D in all of the seven types of skeletal dystrophies listed in Table II, there would be a positive balance *except* in generalized osteitis fibrosa, in which the balance is consistently negative; the serum calcium is high; the plasma phosphates are low; and true adenomata of one or two of the parathyroid glands are found in nearly all cases at operation or postmortem examination.[28]

Excision of a true adenomatous tumor of a parathyroid gland has resulted in relief from symptoms or improvement in each case. Churchill [29] has supplied further evidence to support the belief that in all cases of true hyperparathyroidism an adenoma of a parathyroid gland is present.

SUMMARY

Generalized osteitis fibrosa may be differentiated from other skeletal dystrophies which are clinically similar. This condition is characterized by a high serum calcium content, low plasma phosphates, increased excretion of calcium in the urine, and negative calcium balance; an *adenomatous* tumor of one or more parathyroid glands has always been found at postmortem examination and nearly always at operation, while the remaining glands are normal in size and structure.

There is no good evidence that Paget's disease is caused by hyperparathyroidism. In this condition the calcium and inorganic phosphate content of the blood are normal; the calcium balance in the chronic phase of the disease is markedly positive; the output of urinary calcium is greatly decreased; and the parathyroid glands are usually found to be entirely normal in size and in microscopic structure.

Ankylosing polyarthritis is probably not caused by hyperparathyroidism because, in this condition, although the serum calcium may be slightly above normal, the inorganic phosphates of the plasma are normal; the calcium balance is positive; the parathyroid glands have been reported enlarged, but usually this enlargement was symmetrical, involving all of the parathyroids similar to that reported in cases of rickets or low calcium osteomalacia. In experimental animals the addition of vitamin D and of adequate calcium and phosphorus to the diet will result in decrease in size of the enlarged parathyroid glands as well as healing of the skeletal disease.

Parathyroidectomy in cases of ankylosing polyarthritis or of Paget's disease is not a justifiable procedure unless there is more adequate evidence of parathyroid gland pathology than has been presented in reports of cases in the literature.

Demineralization of the skeleton in polyarthritis may be accounted for as atrophy of disuse.

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CONSIDERATIONS ON THE USE OF PARATHYROIDECTOMY FOR ARTHRITIS

BY I. WILLIAM NACHLAS, M.D., BALTIMORE, MARYLAND

Parathyroidectomy has been performed for the cure of arthritis and favorable results have been reported in some patients. Arthritis is so widespread, the suffering produced by it is so great, and the accepted methods of therapy are so unsatisfactory that any new method of treatment that offers relief is to be welcomed with open arms. On the other hand, the possibility of introducing dangerous complications by the use of any new method demands considerable caution and a careful study of contra-indicating factors.

Under the heading of arthritis we classify a heterogeneous group of clinical syndromes. It is quite likely that this heading covers a variety of diseases which differ not alone in their pathology but also in their etiology, and have a common denominator only in their visible point of attack,—namely, joint surfaces. One would hardly give credence to any proposed single cure for all classes of dermatitis, though the point of involvement is the same in all of these conditions. In the same way, one can hardly accept any one method of cure for the numerous ailments which happen to have as their common interest only a predilection for synovial membranes. It is, of course, conceivable that arthritis of a very limited type may result from changes in the adjoining bones, such changes being produced by abnormal parathyroid action. But it would be illogical to accept as a corollary the statement that arthritis can be cured by parathyroidectomy.

The use of parathyroidectomy as a therapeutic procedure in arthritis predicates disturbance of the lime-salt metabolism and is based on the fact that the parathyroid secretion mobilizes these salts. While the evidence is quite convincing that calcium-phosphorus deposits in the bone are affected by these endocrine glands, one can hardly accept, without some doubt, the statement that arthritis is a disease of mineral-salt metabolism. Calcium determinations have been made in arthritis by many observers, but the reports have varied. Some investigators report a marked increase in the blood calcium, others a marked deficiency. The writer has studied the serum calcium in thirty-seven cases but has found no change from the normal. In the same thirty-seven patients the blood phosphorus was studied with the idea of differentiating the hypertrophic from the infectious arthritic, but no uniform variation from normal readings was obtained. The only deduction that could be made was that the phosphorus level is lower in the osteo-arthritic than in the infectious arthritic. In fact, it is quite likely that phosphorus rather than calcium is the determining factor in these studies on calcification, a fact which is confirmed by subsequent studies. On the other hand, studies on individual specimens

of blood are likely to be incomplete because we have reason to believe that the blood is merely a vehicle transporting the calcium and phosphorus ions to and from the skeletal system without giving any accurate data as to the bone supply in this system. Certainly, from the data that we have on the mineral metabolism in arthritis to-day, we have no right to assume that arthritis is the result of calcium-phosphorus dyscrasia.

The action of parathyroid secretion is receiving considerable study, but our knowledge of this is still in such an undeveloped state that interference with the function of these glands can easily prove to be a double-edged sword. Most of the parathyroid therapy for bone conditions is based on the assumption that the hormone removes lime salts from the osseous tissue,—that is, that osteoporosis results from excessive parathyroid secretion in the body. Recent investigations indicate that this action is definitely a matter of dosage. It has been shown that injections of parathormone in rats can, in given doses, produce osteoporosis; while in others osteosclerosis results. Furthermore, the effect of parathormone in animals varies decidedly with the calcium-phosphorus intake. In other words, the diet is linked with the whole problem. If we are to expect some given effect on bone deposits from the use of this hormone, we shall first have to have a much more accurately correlated fund of information on dietary studies and effect of dosage of parathormone.

One other thought presents itself, and that is the question of what becomes of the lime salts that are moved from the skeletal system. Laboratory experiments have shown that the liberated calcium phosphate may be deposited in other areas,—such as the blood vessels and the kidneys, where as vicarious calcification very severe complications are produced. The importance of accurate knowledge on the production of such calcifications need hardly be stressed, since obviously the cure may prove to be much more serious than the disease. Surely it would appear desirable at the present time to entrust the proposed parathyroidectomy for arthritis to capable investigators rather than to accept it as a determined curative method for arthritis.

CORRECTION OF COMPRESSED AND IMPACTED FRACTURES OF THE VERTEBRAE *

BY JOHN DUNLOP, M.D., AND
CARL H. PARKER, M.D., PASADENA, CALIFORNIA

Compressed impacted fractures of the vertebral bodies are no longer a rarity in the practice of the orthopaedic surgeon. This is due to two causes,—first, to the fact that with better x-ray equipment and technique the diagnosis is made more readily; and, second, to the universal use of the automobile, in our community the greatest single factor in the production of this injury. The automobile accident usually happens in the following manner,—The machine is driven at high speed through a dip or "thank-you-ma'am"; the individual on the back seat is thrown up to the top and then falls in the flexed position, thus producing the injury.

The characteristic symptoms of compression fractures which call for a thorough roentgenographic examination are:

1. History of adequate trauma;
2. Sudden severe localized pain at the time of injury;
3. Continued discomfort for hours and days following the accident;
4. Girdle pain.

The frequency of the injury is shown by the fact that since October 1927, we have treated fifty-eight compressed or impacted fractures, and in addition there have been a very considerable number treated by other surgeons in this community. It must also be distinctly understood that the type of case we are discussing excludes those with any cord injury. The future will decide whether similar treatment can be applied to such a group.

The experience of surgeons in various parts of the United States has demonstrated that compressed and impacted fractures can be corrected. To Davis of Erie, belongs the credit of being the pioneer in this field, and certainly his results have proved the possibility of success. The Boston school headed by Rogers has obtained equally striking results in a more conservative way. Both of these methods have accomplished excellent reductions.

Our method, though more bold than either of these, has the merit that the reduction is accomplished with ease, rapidity, and certainty. The result may be immediately checked by examination by a portable x-ray apparatus. We are of the opinion that the large number of reductions that have now been made, and the length of time which has elapsed, warrant general adoption of the procedure in most cases, if uncomplicated by cord injury.

* Presented at the Annual Meeting of the American Orthopaedic Association, Toronto, June 18, 1932.

FIG. 1

Case 1. Mrs. O. This case illustrates the most common type of simple compression fracture through the upper third of the body.

FIG. 2

Case 1. Mrs. O. An example of the nearly perfect reduction which can be attained in the ordinary cases.

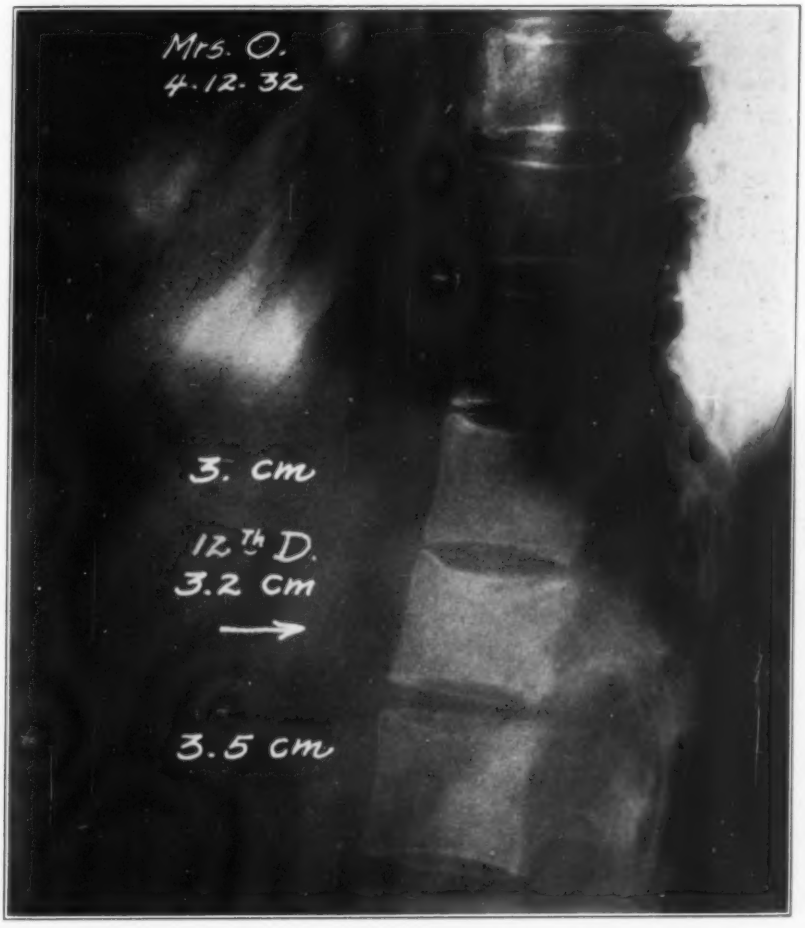

FIG. 3

Case 1. Mrs. O. Five months after reduction. The normal bone texture indicates that the strength of the bone has been restored.

The group which we have treated includes the cases seen within a week of the injury, and does not include old unrecognized cases in patients who have come in for painful backs.

JUSTIFICATION

With the introduction of such a radical change in the treatment, a number of questions have arisen as to the advisability of the procedure.

1. Are the results following such a procedure any better than with the old method of non-interference?

2. Does such a fracture heal after reduction by building new bone of sufficient strength to sustain the superincumbent body weight?

3. Can reductions be accomplished with sufficient certainty and safety to warrant the adoption of this method as a routine procedure?

4. In what way is treatment by reduction superior to an operation which results in fusion of the injured segments?

In answer:

Question 1. Are the results following such a procedure any better than with the old method of non-interference?

Yes, for these reasons:

A. Reduction of the fracture restores the normal alignment of the vertebral bodies, eliminates kyphosis and lateral deviations, and thus improves the general posture.

B. By restoring the normal relations of the articular facets, free movement of the spine is assured, and irritation is eliminated.

C. The hyperextension diminishes nerve-root pain.

D. The development of bone spurs and the bridging of the intervertebral spaces is less likely to occur, thereby assuring a more flexible spine.

Question 2. Does such a fracture heal after reduction by building new bone of sufficient strength to sustain the superincumbent body weight?

In the roentgenograms you will see that the bone has been rebuilt with remarkable solidity, and that in many instances the normal architecture has been so completely restored that the site of fracture cannot be recognized.

Question 3. Can reductions be accomplished with sufficient certainty and safety to warrant the adoption of this method as a routine procedure?

Yes. The roentgenograms shown here give a true picture of what can be accomplished. There has never been a single instance of injury to the spinal cord as a result of the reduction. The disagreeable symptoms which have followed the procedure have been limited to localized pain, nausea, and vomiting lasting two to three days, which may fairly be attributed to the marked hyperextension in the cast and to the anaesthesia. Two cases have had temporary ulnar palsies, which I believe to be due to the poorly applied traction with the sheet in the axilla.

In the entire group of patients two have died, one a year afterward from a cause not in any way related to the fracture; the other had a severe cystitis on admission and died of pneumonia seven weeks after the reduction.

Question 4. In what way is treatment by reduction superior to an operation which results in fusion of the injured segments?

Reduction results in a flexible spine, in place of a stiff spine with deformed segments.

Eikenbary's statistics indicate that fusion operations do not give results superior to those obtained by simple fixation.

PSYCHOLOGICAL EFFECT

An essential procedure in treating these patients is to procure their active cooperation and their confidence by showing them the roentgenograms made before and after reduction, and those taken after the removal of the cast, which show the solid healing of the injured bone.

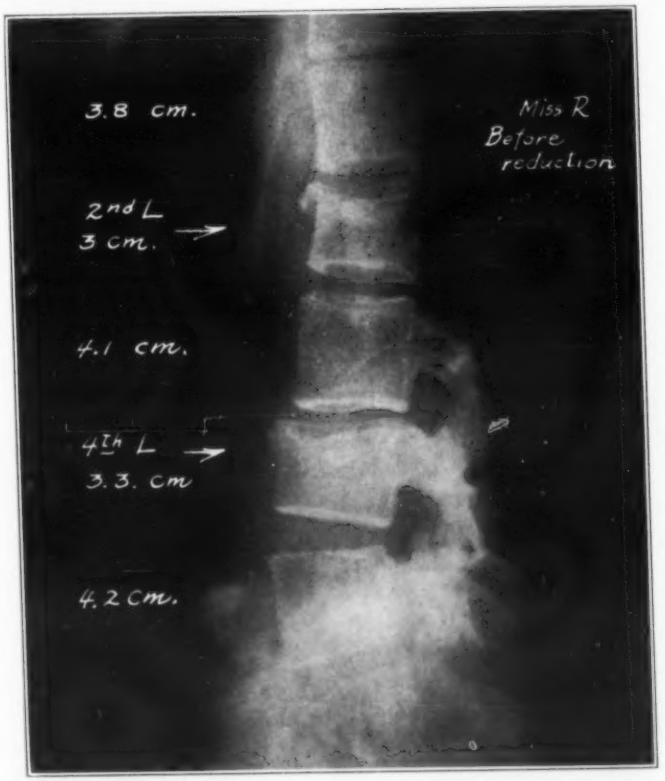

FIG. 4

Case 2. Miss R. Before reduction. Two vertebrae are fractured. Instances of injury to more than one bone are frequent.

FIG. 5

Case 2. Miss R. Four months after reduction. The front of each vertebral body is now of normal height, the upper cortical plate of each bone still shows some deformity due to incomplete reduction.

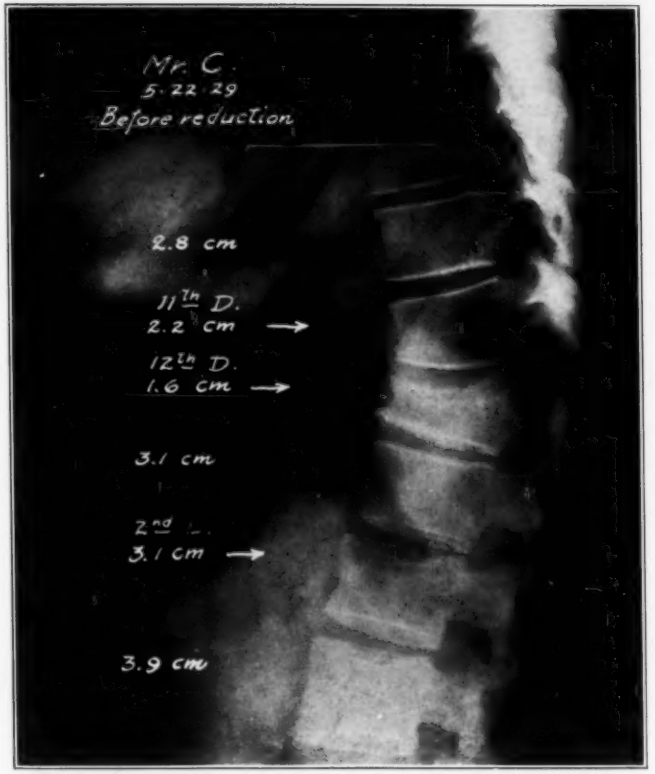

FIG. 6

Case 3. Mr. C. Multiple compression fractures of varying severity. Three vertebrae were injured.

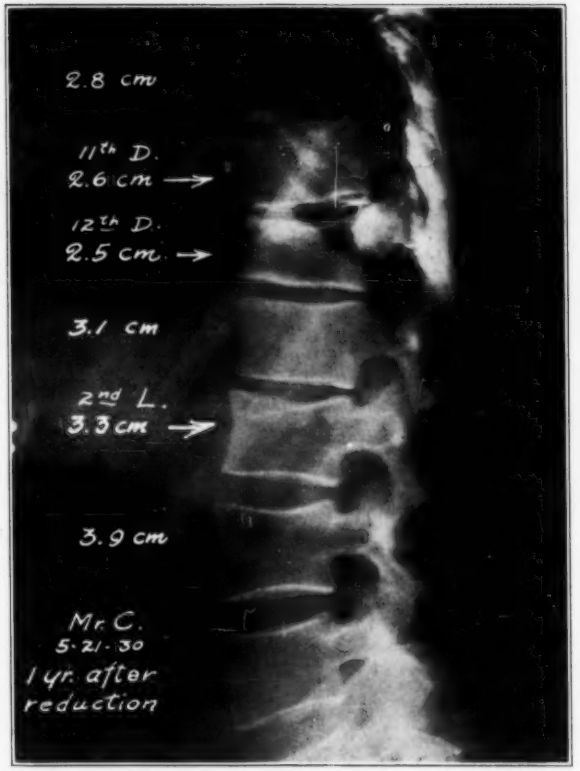

FIG. 7

Case 3. Mr. C. One year after reduction. An excellent reduction of the eleventh dorsal vertebra was obtained. The twelfth dorsal shows a fair reduction and good repair of the bone. The front of the body of the second lumbar vertebra was correctly reduced, while a part of the upper cortical plate remains depressed. This may be a result of injury to the intervertebral disc.

This may be a result of injury to the intervertebral disc.

FIG. 8

Case 4. Mr. R. Before reduction. Compression, comminution, and kyphosis were all present.

FIG. 9

Case 4. Mr. R. After reduction. A remarkable restoration of the form, size, and alignment of this vertebral body was obtained by controlled forcible hyperextension. The firm attachments of the bone to the anterior longitudinal ligament and to the discs must play an important part in bringing the fragments into position.

In the Industrial cases the demonstration of the serial films before the Accident Commission should result in a fair award, instead of the high permanent disability ratings which have been the rule during recent years. The serial films are of equal importance in the medicolegal cases.

METHOD OF REDUCTION

The essential steps in the procedure can be enumerated as follows:

Anaesthesia sufficient to obtain complete relaxation.

Breaking up the impaction or overcoming the compression by forcible hyperextension during traction.

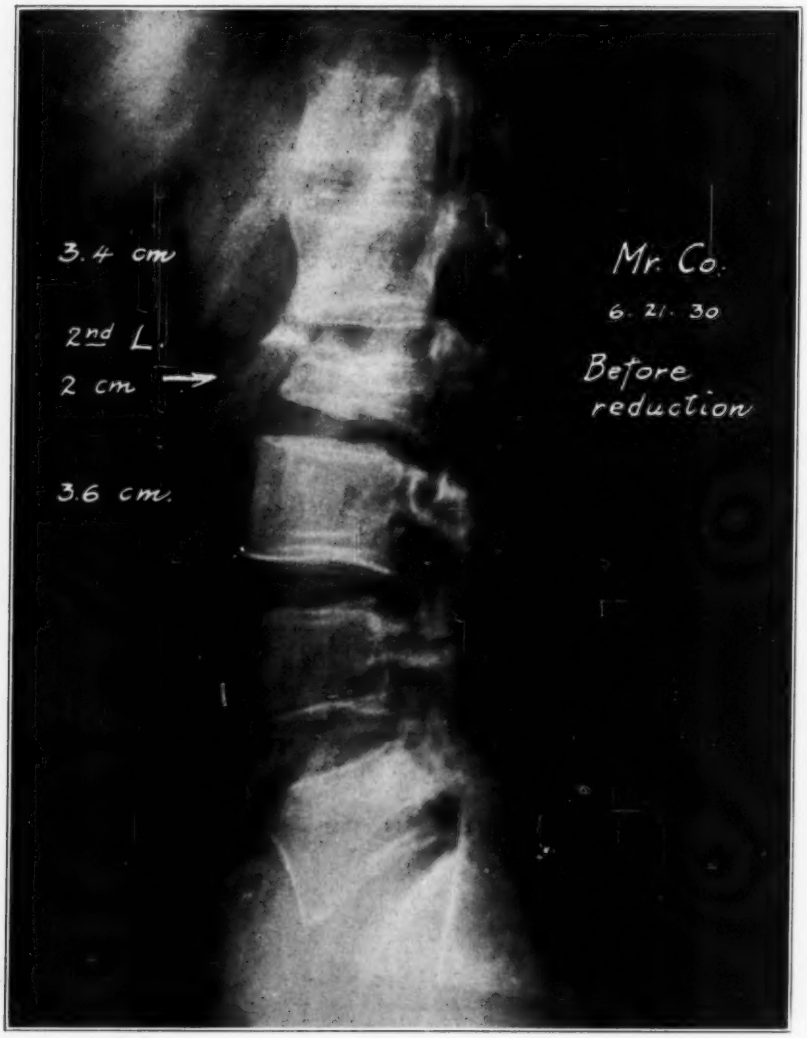

FIG. 10

Case 5. Mr. Co. Before reduction. The body of the second lumbar vertebra was badly comminuted and compressed.

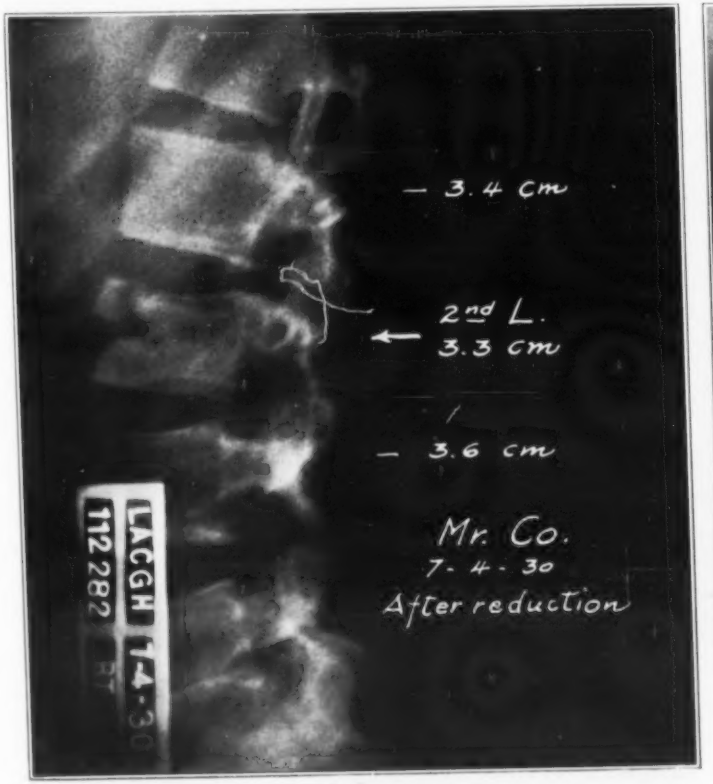

FIG. 11

Case 5. Mr. Co. After reduction. In spite of the comminution, the height, form, and alignment of the body were remarkably well restored by the reduction.

FIG. 12

Case 5. Mr. Co. Ten months after reduction. This case demonstrates the amount of bone repair which can take place. Note the strength of the new bone. Narrowing of the intervertebral space above was attributed to injury to the intervertebral cartilage.

Reduction by placing the patient in marked hyperextension on a Goldthwait frame.

Application of a plaster jacket for permanent fixation in the corrected position.

Since it is of moment to follow the procedure with exactness, the minute details of the simplest and surest method will be described.

1. The preparation of the Goldthwait frame is of great importance. The bars chosen must be of such strength that they will sustain the patient's weight without undue yielding; on the other hand, the steel must be sufficiently compressible so that it will mold to the curve of the individual back. These bars are then bent to produce the maximum hyperextension in the individual, taking into consideration the location of the injury, the flexibility of the spine, the age and weight of the patient. The patient is then covered with stockinette and heavy felt is prepared for proper padding of the back.

2. The patient is put to sleep with gas, and is then given ether continuously in sufficient amounts to secure complete relaxation during the reduction and until the cast has been applied.

3. The patient is placed on the Goldthwait bars.

4. Extension and counterextension are applied by three or four assistants. The extension is obtained by direct pull on the legs and the counterextension by pull on sheets folded across the chest and under the opposite arm.

FIG. 13

The Goldthwait bars are here clearly shown with the curve used to maintain strong hyperextension. The heavy felt is used to pad the entire back during the four months in the cast. Time is essential for complete bone repair.

5. The operator stands on a platform of such height that his shoulder may be brought directly over the patient. A folded sheet is passed beneath the injured segments and is tied over the operator's shoulder. Then, while the assistants are applying the longitudinal extension and counter-extension, the operator applies controlled forcible hyperextension by lifting upward with his own back and shoulder. This movement results in the breaking up of the impaction. Several methods of breaking up the impaction have been tried. (One was described by the authors in the issue of *Radiology*

for August 1931, XVII, 228. Another method which has been used with success substitutes block and tackle suspended from the ceiling for the operator's shoulder.)

6. The patient is then adjusted on the frame and the result is immediately checked by a lateral view of the injured vertebra made with a portable x-ray machine.

7. As soon as a satisfactory reduction has been demonstrated, a plaster jacket is applied, extending from the clavicle to the pubis. A circular window, six inches in diameter, is cut in the cast over the epigastrium. A pillow is placed beneath the curve of the back while the cast is drying, in order to preserve the hyperextension.

8. In the after-care we have found it to be a great comfort to the patient to elevate the head of the bed about four inches. During the last four weeks in bed, massage and exercises for the legs should be given.

9. The patient is kept in the cast a minimum of fifteen weeks. Time is essential to the healing of the spongy and porous bone which makes up most of the structure of the vertebral body. Remember that this bone must be of sufficient strength to support the weight of that part of the patient's body above the injury.

During the time in the cast the patient is kept in the supine position, and is never turned completely on his side, and is never turned prone. For purposes of nursing care he may be turned eighty degrees from the supine position.

FIG. 14

This photograph illustrates the original method of reduction. A folded sheet has been passed beneath the injured segment. The ends are held by the operator and his assistant. Other sheets are crossed over the chest to permit strong counter-traction upward. The traction on the ankles is not shown. The arms are held out of the way by tying the wrists together.

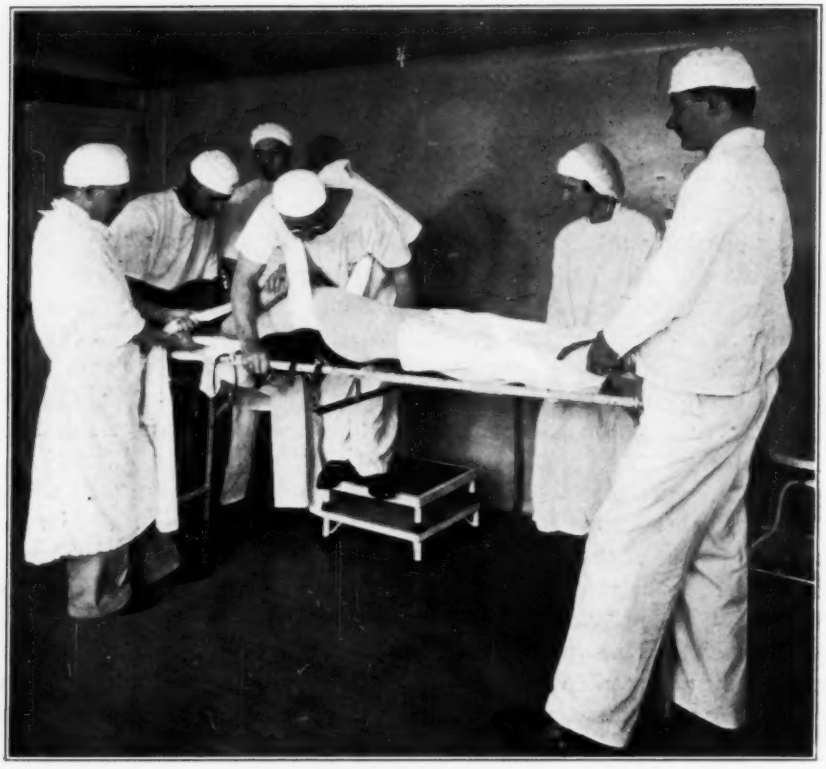

FIG. 15

This less radical method of applying the reducing force has been used where the injury has caused comminution of the body without deep impaction.

10. When the cast is removed, x-ray studies should show complete reproduction of the bone.

11. At sixteen weeks, the patient should be fitted with a Taylor back brace which is to be worn up to a year from the time of the injury.

It has been a surprise to see how perfectly the simple compression fractures may be brought into position; even where the bodies of the vertebrae are comminuted, the various fragments return to a nearly normal relation under this treatment, doubtless as a result of the firm ligaments that surround the bones and the close attachment of the compact upper and lower vertebral plates to the intervertebral discs. When the structure of the bone is taken into consideration, it is remarkable that the repair is so satisfactory. Filling in of fairly large spaces has been obtained and when once the new bone has been built, it appears to have ample strength to sustain the weight placed upon it. One patient, a stockily built motor-cycle officer, was able to return to active duty on his machine seven months after his injury. Subsequently he sustained two heavy falls from his motor cycle without any sign of injury to the repaired vertebra.

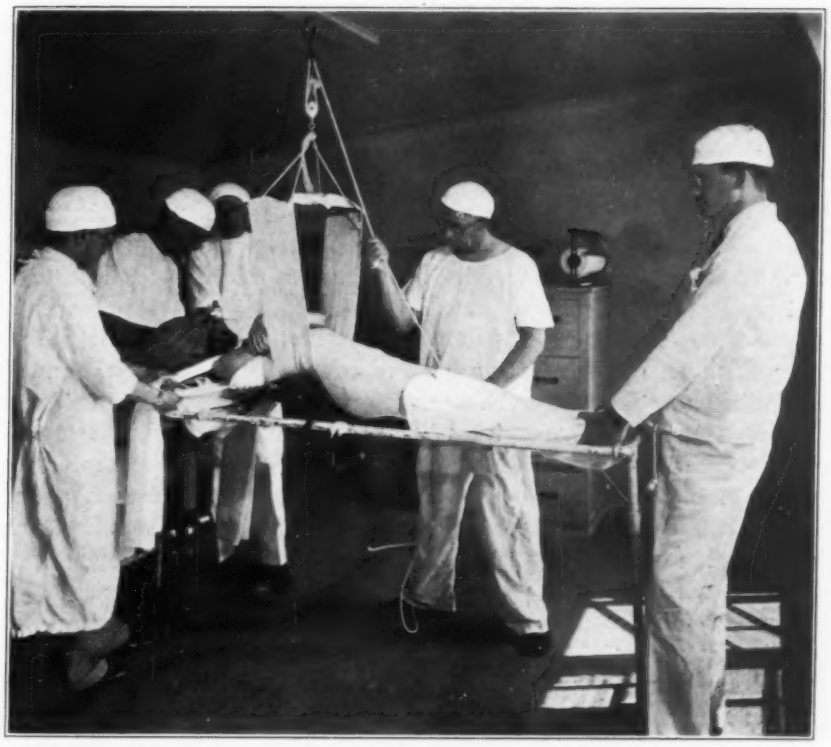

FIG. 16

A third method of reduction by the use of a sling and a block and tackle is the choice of some operators. Hyperextension is easily maintained while the patient is lowered on to the Goldthwait bars.

The more severe the bone injury, the less perfect is the reduction. This has been especially true where there has been much depression of the lateral portions of the vertebral bodies and where there have been central depressions. The fractures of the dorsal vertebrae above the ninth have not yielded as good results as when the injuries have been below this point. This we have attributed to the rigidity of the thoracic cage.

Damage to the intervertebral discs has been rather frequent, as evidenced by partial loss of the intervertebral spaces adjacent to the broken bones in the final roentgenograms. Several of the films have shown the appearance of localized protrusions of the nucleus pulposus.

At the suggestion of Dr. Kellogg Speed, a statistical study of final results in this group of cases is to be deferred until a large number of patients have been followed for a period of at least five years. The value of treatment by reduction must also be tested by the experience of many operators in different parts of the country.

The number of cases with cord injuries, which have been reduced, is still too small to warrant a report at the present time.

AN OPERATION TO MAKE A POSTERIOR BONE BLOCK AT THE ANKLE TO LIMIT FOOT-DROP*

BY A. BRUCE GILL, M.D., PHILADELPHIA, PENNSYLVANIA

To Dr. Willis C. Campbell belongs the credit of originating an operation to limit plantar flexion of the foot by means of a posterior ankle bone block. His operation was the first effective solution of the problem in certain groups of cases.

The author has used the following method of operation for the past five years as it has appeared a little more simple in technique than the Campbell operation, but not more effective.

But comparatively few individuals who have deformity of the foot from infantile paralysis require a bone-block operation to correct foot-drop. Talipes equinus, when present, is usually combined with a lateral deformity of the foot and frequently can be corrected when a stabilizing operation is performed for the correction of the latter. A lengthening of the tendo achillis; the transplantation of a lateral muscle forward to the dorsum of the foot; even the comparative lengthening of the tendo achillis that occurs when the subastragalar joint is excised in doing a subastragalar arthrodesis; the moving of a flail foot backward, as in a Davis horizontal transverse section, so that the heel tends to balance the anterior part of the foot, together with the production of scar tissue that results from freeing the lateral ligaments of the ankle from their malleolar attachments—all of these procedures tend to correct an ankle foot-drop.

The author has found the bone-block operation useful in two types of cases. One type is the flail or dangle foot. There is a complete paralysis of all muscles. When the patient lifts his foot from the ground the weight of the anterior part of the foot causes it to drop. Unless the patient raises his knee higher than normal in walking and gives his foot a peculiar fling his toes scrape the ground or catch on some irregularity and trip him. If you stand behind him as he walks away from you in his bare feet, you see at every step the plantar surface of the foot. A stabilizing operation for lateral deformity of the foot may or may not be necessary, or one may have already been done.

If such operation is indicated the author employs the procedure published in a former paper.[1]

"A subastragalar arthrodesis will correct any tendency to a lateral deformity but will not correct the dropping of the foot in front. A horizontal transverse section with moderate backward displacement of the foot will correct the foot-drop as well as the lateral deformity. The foot need not be placed backward so far as in cases of decided calcaneus, nor is any anterior bone-block required. Two factors probably are active in preventing the dropping of the foot: first, the relative increase in weight of that part of

* Presented at the Annual Meeting of the American Orthopaedic Association, Toronto, June 17, 1932.

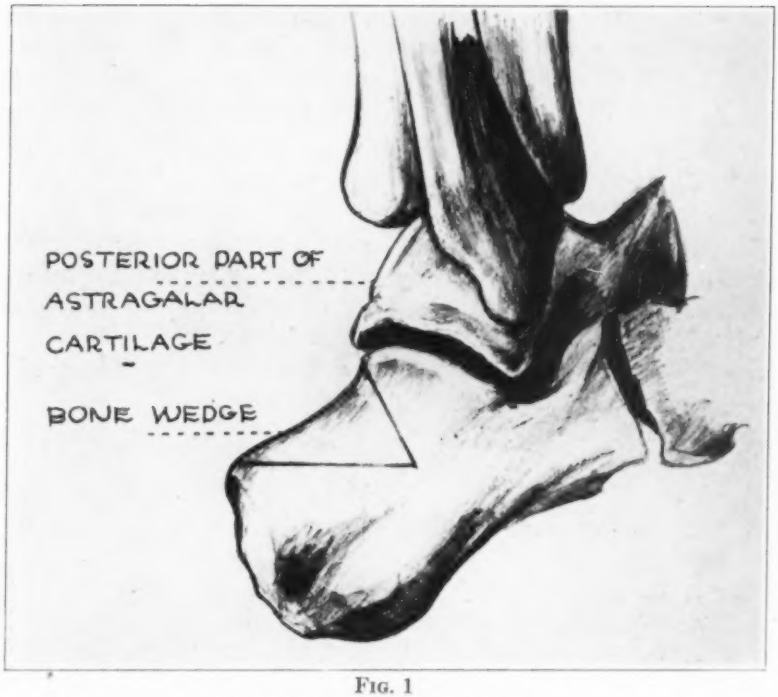

FIG. 1
Showing the foot in dorsiflexion.

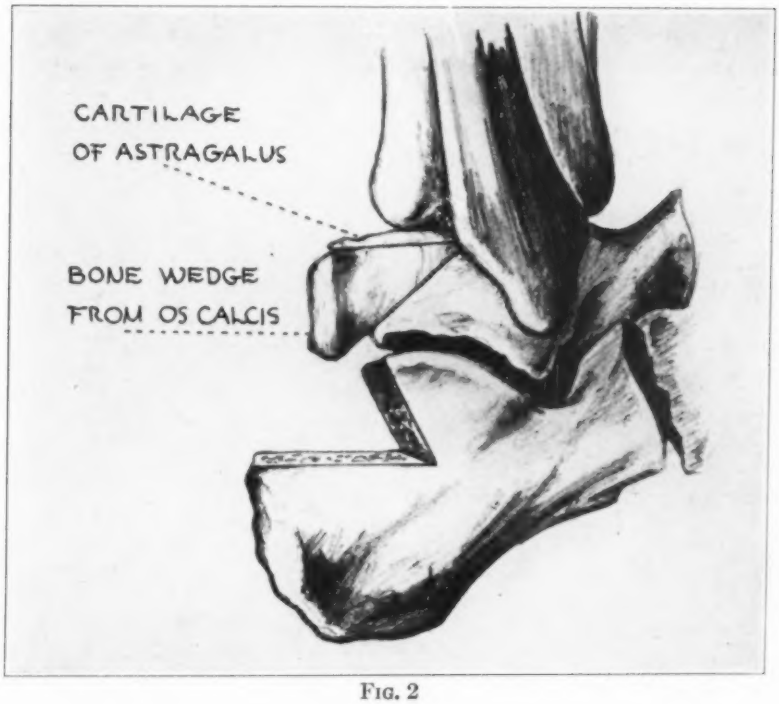

FIG. 2

the foot which is behind the ankle joint which tends thus to balance the weight of the anterior part, and, second, the scar tissue which forms about the ankle joint after the lateral ligaments have been elevated subperiosteally from the malleoli."

If foot-drop has not been corrected in some such manner at the time of a fusion operation, a posterior bone block is indicated; or the two operations may be combined at the same time, if the surgeon so desires.

The second type of case is that in which a strong tendo achillis is not balanced by anterior muscles. In this type a posterior ankle block is the only sure method of correction that the author knows, aside from an arthrodesis of the ankle, which, of course, is out of the question. It may be noted in passing that if there is a paralysis of the quadriceps femoris muscle, a moderate foot-drop with a tight tendo achillis is desirable in stabilizing the knee.

DESCRIPTION OF THE OPERATION

A skin incision is made parallel to the tendo achillis. The latter is exposed and divided Z-fashion. An incision is then made longitudinally through the underlying fat which is then scraped to both sides to expose the posterior aspect of the ankle joint and the top of the os calcis. The ankle joint is opened.

The foot is dorsiflexed to the limit of motion. This brings the posterior portion of the articular surface of the

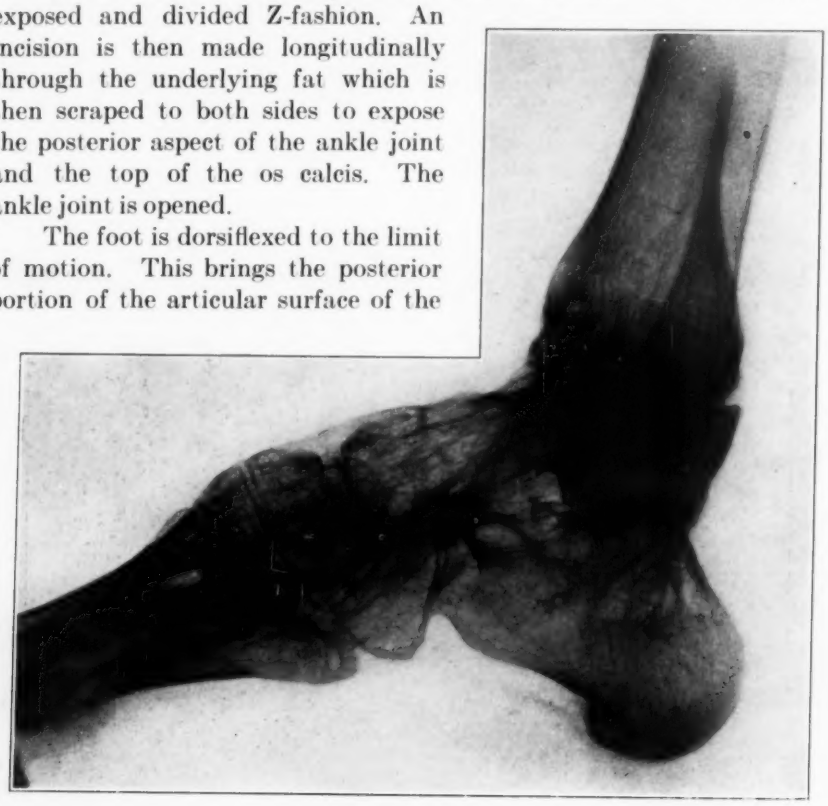

FIG. 3

Showing final result of bone block two years after operation. Note that the space in the os calcis from which the bone wedge was removed is now fairly well filled in with new bone.

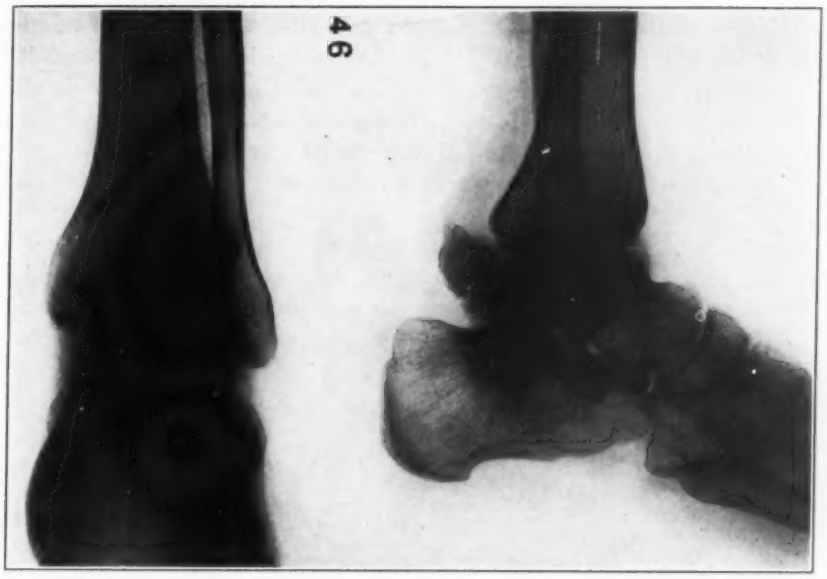

FIG. 4
Showing result one and a half years after posterior bone-block operation.

astragalus into view into the wound as shown in Figure 1. Sometimes the astragalus has a tail which extends beyond the cartilage, sometimes it does not.

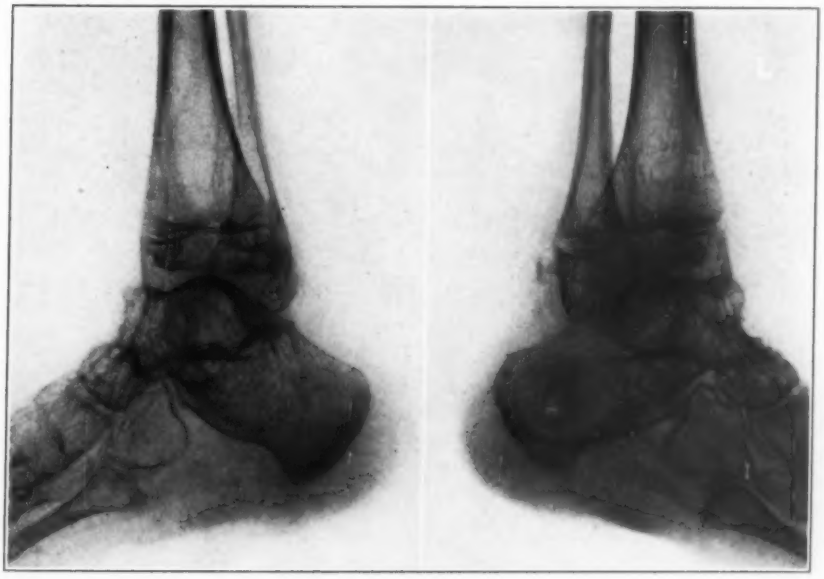

FIG. 5
Showing result of anterior ankle bone-block for calcaneus eighteen months after operation.

With a broad, thin osteotome the cartilage, with a thin portion of bone of the astragalus, is lifted upward from behind until it comes into contact with the posterior lip of the tibia. The angle of the wedge-like space thus formed lies well forward beneath the cartilage and in front of the posterior lip of the tibia. If the surgeon is careful, this plate of cartilage and bone bends upward at its anterior aspect without breaking off (See Figure 2).

A wedge-shaped piece of bone is then removed from the upper aspect of the os calcis and is driven firmly into the space beneath the superior portion of the astragalus. It will then be observed that the foot is maintained firmly in a position of dorsiflexion.

The tendo achillis is sutured with the necessary amount of lengthening. The skin wound is closed with No. 0 or No. 1 twenty-day chromic gut. The foot is dressed in plaster in slight dorsiflexion for three months.

The merits of this method of operation are its simplicity, the ease and speed with which it is done, the fact that no other incision or operation is required to obtain bone for the wedge, and the fact that it has withstood the test of time.

1. GILL, A. BRUCE: Fusion Operation on the Foot. J. Am. Med. Assn., LXXXIX, 1829, 1927.

CONGENITAL METATARSUS VARUS *

BY CHARLES W. PEABODY, M.D., AND FELIPE MURO, M.D., DETROIT, MICHIGAN

This paper represents a study of a certain typical congenital deformity of the foot, which in the English current literature of the last twenty-five years has received only one—and that a comparatively brief—reference, and which the current English orthopaedic texts either fail to describe entirely, or give only passing mention. Yet this study is based on some fourteen cases nearly all encountered in one clinic in the past five years. Since 1904 the Continental current literature has provided a respectable bibliography, although leaving an impression quite inconsistent with the frequency with which this deformity has been met in the period covered by this study. Because of their relatively close similarity, the series includes some cases in which the term congenital metatarsus adductus may be more exact, and some in which the available data has not permitted differentiation. The previous literature also has tended to group the two types without always recognizing them as separate entities. The general deformity being considered here, when occurring in a major grade, has certainly such well defined differential characteristics as to make it absolutely separable from congenital talipes equinovarus as a clinical entity. However, in a minor grade it might easily fail to demand attention from absence of any obvious effect on function, or from being mistaken for a mild residual of talipes equinovarus.

Classification of our deformity with common club-foot seems quite improper from a number of striking factors in the pathology. In the first place, equinus is never present in any degree. In the second, the sole of the foot is always flat, or nearly so. Thirdly, in spite of a first impression of a varus foot, there is seen to be no ankle varus or supination at the subastragaloid joint, but, on the contrary, valgus or pronation, with marked inward rotation and luxation of the head of the astragalus, the scaphoid and mesial cuneiform being displaced laterally. Although this posterior foot deformity might be an inevitable compensation from functional adaptation to a preexisting forefoot varus, or to manipulative correction thereof, the European literature contains a report (Nové-Josserand) of a postmortem dissection in a three months-old untreated case, in which the tarsal valgus was a notable feature.

The major element of deformity, of course, involves the forefoot, beginning with the cuneiform bones, which are rotated in a varus direction and are abnormally overlapping, so that the upright perpendicular might pass through all three of these bones. More striking is the deformity of the metatarsals. To a slight degree the fifth and to a marked degree the fourth, third, and second metatarsals are incurved in their diaphyses

* Presented at the Annual Meeting of the American Orthopaedic Association, Toronto, June 17, 1932.

and to some degree dorsally convex. The first metatarsal is usually straight, but articulates at its base with the mesial aspect of the inner cuneiform and makes a marked varus angle with the mesial aspect of the foot back of this point, the greatest concavity being between scaphoid and metatarsal, and the cuneiform tending toward a lateral position with respect to the scaphoid.

In our series the younger cases, however, have shown frequently no incurving of the metatarsals, but a distinct adduction deviation of the metatarsus on the tarsus, but with the same abducted or valgus position of the calcaneum and inward rotation and depression of the talus. It is this group that present the possibility of a separate classification of "metatarsus adductus". Yet the stresses resultant from walking on this type of foot would be very likely to bring about the incurving and luxations noted in the older cases. The typical cases of this latter pathology described in the literature were not observed in early childhood. On the other hand, one case in our series was a six-weeks-old infant with x-rays showing most indisputably some incurving of the shafts of the metatarsal bones, apparently duplicating on the infantile scale the typical deformity of the older cases. This represents the most definite evidence yet offered, apparently, in support of the proposition of metatarsus varus and metatarsus adductus, originating congenitally, as separable clinical entities.

Metatarsus adductus may be a proper description of a common residual stage in the course of treatment of congenital talipes equinovarus, in which the deformities of the posterior foot and ankle have responded to corrective treatment more rapidly and completely. In continuing these efforts, often some overcorrection of the ankle varus results before the adduction of the forefoot has been overcome, and the whole foot will thus contain the criteria of the essayist's lesion of congenital metatarsus adductus,—namely, valgus posterior and varus anterior deformities. Hence for this series we have excluded any cases which had any history of primary equinus deformity. To illustrate this point, x-rays will be shown of a nine-year-old child, in which the pathology is quite typical of congenital metatarsus varus or adductus, but in this case there was an adequate history of original talipes equinovarus and usual treatment.

It may be significant in our series, as well as in most of the previously reported ones, that deformity was not noted in infancy and usually not until walking began, and that the deformity became more apparent as time went on. Functionally, the effect in the smaller children was of tripping and stumbling. In the older children the outer border of the foot became callous and painful, the shoes became out of shape and were quickly worn through, with clumsiness persisting in the gait.

Etiologically, the theories commonly put forward have been those in the past frequently ascribed to talipes equinovarus,—namely amniotic compression; and no theory involving primary structural defect or alteration of anatomical arrangement, etiologically suggestive, has been put forward, with one exception. This was a short contribution by Bank-

hart, about ten years ago, who, after emphasizing both the clinical familiarity of many with this entity, and its absence of recognition in text and literature, reported three cases in children operated upon below the age of ossification of the internal cuneiform. He considered, from his operative inspection, that the latter bone was absent, and by this failure of development was responsible for the deformity. In the light of findings to be described in the following pages, it may be interesting to note that he also mentioned seeing some variation from normal in the insertion of the anterior tibial tendon. All the cases in our series, observed after the normal age of ossification of the internal cuneiform, have shown roentgenologically apparently normal development of this bone, and the same has proved to be the case in the reports in the literature illustrated by roentgenograms.

As will appear in our illustrations, operative findings in one case of this series may indicate another etiological theory. The patient was an eight-year-old-boy with bilateral, typical, congenital metatarsus varus. In planning operative correction, it was decided to free the luxated base of the first metatarsal. On exposure of this area, there was at once noted a distinct, anatomical variation in the insertion of the tendon of the tibialis anticus, which normally inserts in the mesial aspect of the cuneiform. In our case it was found to have no tarsal attachment, but continued distally in its sheath in a partially dorsal position until opposite the shaft of the first metatarsal, meeting this bone at a wide angle, and passing beneath it to the plantar surface, when it seemed to fan out in multiple fibers finding attachment to the plantar fascia or the mesial portion of the transverse metacarpal ligament. The mechanical effect of this arrangement in functional activity would seem adapted to bring about the exact deformity of the forefoot that prevails in metatarsus varus. Identical findings prevailed in both feet of this patient.

Interest in the subject which this operative case aroused led to a review of the other cases available in the files, but opportunity has not yet presented to check the observation as a constant clinical finding by exploration in additional cases; so it is hoped that others may be stimulated to make such investigation.*

From the angle of methods and results of treatment, it may appear that the cases of typical metatarsus varus fall into a different group than those classified as metatarsus adductus. In the latter, manipulative treatment has seemed quite successful and reliable in obtaining correction of deformity, both by functional and cosmetic standards, as well as by those of anatomical skeletal restoration. But in the former the majority of the reports from the literature emphasize the difficulty in obtaining anatomical restoration by any method, and the two cases of major deformity reported here have likewise failed to show, in final x-rays, any very successful result from operative attack, although functionally and cosmetically the feet were greatly improved. Manipulative treatment

*Dr. R. V. Funsten, in a late communication, reports similar findings at operation on a case of this deformity.

carries the drawback that corrective force is required in opposite directions on tarsus and metatarsus, with obvious obstacles to its practical application, so that correction of the forefoot deformity would tend to be at the expense of increasing the tarsal valgus of the posterior foot.

Individual metatarsal osteotomies have been commonly practised, and theoretically seem promising in results, but practically, in accomplishing realignment of the forefoot deformity, such tension and strain on the soft tissue attachments between the several metatarsal bones are involved, that, after simple osteotomies of the latter, there still remains great resistance to correction. Two cases in this series seemed to forcibly demonstrate this point.

Recommendations for operative treatment by various writers have included also: excision of cuboid, resection of the bases of all the metatarsals, osteotomies of shaft, transverse wedge-shaped osteotomy, and incision through Chopart's joint. The writers' observations and experience seem to suggest, in cases of major deformity, indication for attack by the following steps: (1) excision, probably *en bloc* and through a central incision of the bases of the three middle metatarsals; (2) subcutaneous osteotomy of the fifth; (3) mobilization and reduction of luxation of the first metatarsocuneiform joint with appropriate attention to insertion of the tibialis anticus; (4) consequent manipulation to produce a completely abducted and pronated foot. At a later sitting the reconstruction procedure of Hoke should be done in the joint of Chopart, and the posterior foot deformities thus corrected. It seems very doubtful if any program short of this will give an ideal result in a high-grade metatarsus varus, and this procedure probably must be postponed till later childhood. The value of manipulative treatment at an earlier age should be carefully weighed against the possibility of decreasing one deformity at the expense of the other.

Certainly, from this study, it would seem indicated, on encountering forefoot varus in children without history of typical congenital talipes equinovarus, to analyze the set-up of the rest of the foot as well, and to study it roentgenologically before classifying the case or proceeding to corrective measures.

REVIEW OF LITERATURE

In the orthopaedic text-books of Bradford and Lovett, Sever, Albee, Taylor, and Tubby, no mention of metatarsus varus occurs. Whitman, in his text, devotes a few lines, describing the condition only as an adduction of the metatarsals on the tarsus, not mentioning curving of the individual metatarsal bones, and states that it "may be congenital, a variety of talipes varus, but more typically is combined with a posterior valgus as an acquired condition". Jones and Lovett devote about four lines to the condition, in which the lesion is considered rare and described as "an adduction of the phalanges on the metatarsal heads", usually congenital, sometimes acquired.

In the current medical literature in English, the only reference discovered is that of Bankhart in 1921, previously mentioned.

The Continental current literature of the last twenty-five years includes a very considerable bibliography, with a few scattered previous references. The first detailed description and analysis apparently is that of Cramer in 1904, who closely studies and analyzes an adult case, and for the first time considers the possibility of a congenital etiology, previous conceptions having been of an acquired defect.

Helbing, in 1905, reported four cases out of 5000 children admitted to Hoffa's clinic and, in 1909, Froelich brought the literature up to date in report of a single case, in which, however, no mention was made of deformity save in metatarsus; but in 1910 Nové-Josserand published an interesting study of a necropsy dissection in a three-months-old child in which all the deformities were revealed. In 1914 Van Neck reported a good operative result under the title of metatarsus varus, but his x-rays showed only metatarsus adductus.

An excellent review of literature and detailed study of this deformity was contributed by Ettore, in 1921, twenty-nine cases in previous reports being cited, with addition of seven more out of 480 congenital foot deformities at the Clinica Ortopedica of Milan. His own series was the first limited to roentgenologically-shown curving of metatarsal bones, with simple adductus considered less common, and evident in only one case of his series. He was not satisfied with previous etiological theories, and felt that some muscle imbalance must be responsible.

Although since 1921 more than twenty articles have appeared in the European Continental literature, one very outstanding and detailed contribution, that of Madier and Massart in 1923, deserves special emphasis and should be referred to by anyone interested in the subject. These observers report six cases, seen in one year in one clinic, emphasize the double character of the deformity, prefer to subdivide the cases into adductus and varus groups, and stress the posterior variation as the primary difficulty, with the conviction that attack thereon rather than on the metatarsus is the key to correction. The technique used for varus type is deep mesial incision of the Phelps-Kirmisson type, going completely through all soft parts into the joint of Chopart and, in particular, dividing the calcaneoscaphoid ligament. In the adductus type, they recommend intervention on the metatarsals.

In summary, therefore, the literature as abstracted and in many additional single case reports seems to emphasize the not particularly infrequent occurrence of a congenital foot deformity of apparently varus character, yet separable from the common talipes equinovarus, most uniformly combining opposite distortions of hind foot and forefoot, the latter most commonly involving a varus curving of the individual metatarsal bones as well as a mesial distortion of the metatarsus as a whole, but occasionally presenting only an adduction of the metatarsus on the tarsus. Etiological explanations have been theoretical and generally

admitted as unsatisfactory, and have not included any specific developmental defect or variation as causative. With the exception of the adductus group, treatment by a variety of closed and open methods has given only fairly satisfactory results and without complete anatomical restoration. A possible exception appears in the report of Madier and Massart although not adequately supported by postoperative roentgenograms.

CASE STUDIES

The cases studied by the writers number fifteen, six single, the remainder bilateral. Fourteen have been classified as either primary congenital metatarsus varus or as metatarsus adductus. Of these, seven were male and seven female. The additional case is presented as illustrating, at the age of nine, a deformity of mild grade, but combining the fundamental characteristics of the primary deformity, including some curving of the individual metatarsals, with evidence indicating a typical talipes equinovarus at birth with the usual treatment thereof. Of the series typical x-ray evidence is available in ten, with the remainder receiving clinical observation only, and so not permitting positive subdivision into varus and adductus types. However, in this smaller observed group, the history was specific, the clinical description exact, complete, and supplied by an experienced observer, some possible cases not meeting these qualifications being thrown out. The whole group represents cases observed during a period of five years, and, with exception of one case, in a single, though rather large, orthopaedic clinic.

FIG. 1

Case 1. Wm. Y. Preoperative roentgenogram.

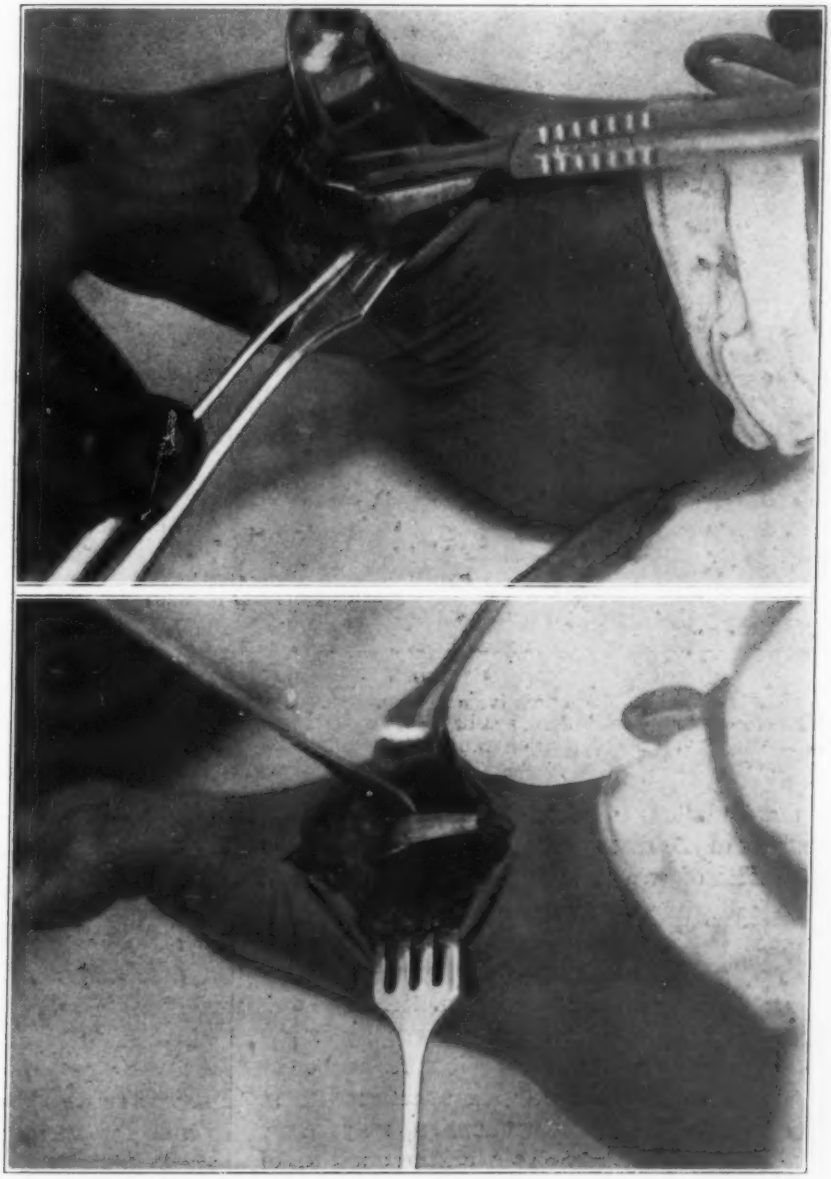

FIG. 2

Case 1. Wm. Y. Operative findings. Tendon of tibialis anticus exposed and retracted as it lies free in its sheath beside the shaft of the first metatarsal bone. Knife blade lies in intervening space. Tendon continues under ball of foot toward other metatarsal heads.

Of the group in which roentgenograms are available, eight are classified as varus cases, two as adductus; three of the former were treated by bone operations, the deformity being extremely high-grade in two; the case reports of these are included in detail. The remainder were treated

FIG. 3

Case 1. Wm. Y. Postoperative roentgenogram. Compare with Fig. 1. Some success in restoring relationships at base of first metatarsal. Forefoot is straighter, but posterior valgus and anterior varus still make long axis of foot sinuous in spite of extensive surgery.

by manipulation, but few of this group are found to have final x-rays. The ages of the cases treated ranged from two to eight years. Clinically the results of treatment of all were judged satisfactory, except in one child of eight in which case there was a relapse. The high-grade cases were greatly improved functionally and cosmetically, but by x-ray standards left much to be desired. Case 1, referred to in the introduction, may throw some light on the question of etiological factors.

FIG. 4

Case 1. Wm. Y. Before operation.

CASE 1. Wm. Y., aged eight, (Case No. 3498, Sigma Gamma Clinic) had history of bilateral deformities, first noticed at six months of age (Figs. 1, 2, 3, 4, and 5). With walking, deformity seemed to gradually increase, until the outer border of the forefoot only was used, and the shoes would not retain their shape.

FIG. 5

Case 1. Wm. Y. After operation.

Interfering and stumbling was a marked factor in earlier years. Examination showed pronation of os calcis, mesial luxation of head of the talus, with convexity of the inner border of the foot in its hind portion, but with a sharp concavity in the mesial border at the joint of Lis Franc, the forefoot of the mesial border being in sharp varus to the end of the big toe. The outer border of the foot was markedly convex in its anterior two-thirds. (The angle of photography tended to underemphasize these findings.) In walking, the varus element seemed more marked; progression seemed to be off the outer border of the metatarsus,

FIG. 6

Case 2. Alice D. Before operation.

FIG. 7

Case 2. Alice D. After operation. Note contrast with postoperative x-ray findings.

FIG. 8

Case 2. Alice D. Postoperative roentgenogram. Original films lost, but a great deal of correction has been obtained. Note, however, residual disturbed relations at base of first metatarsal.

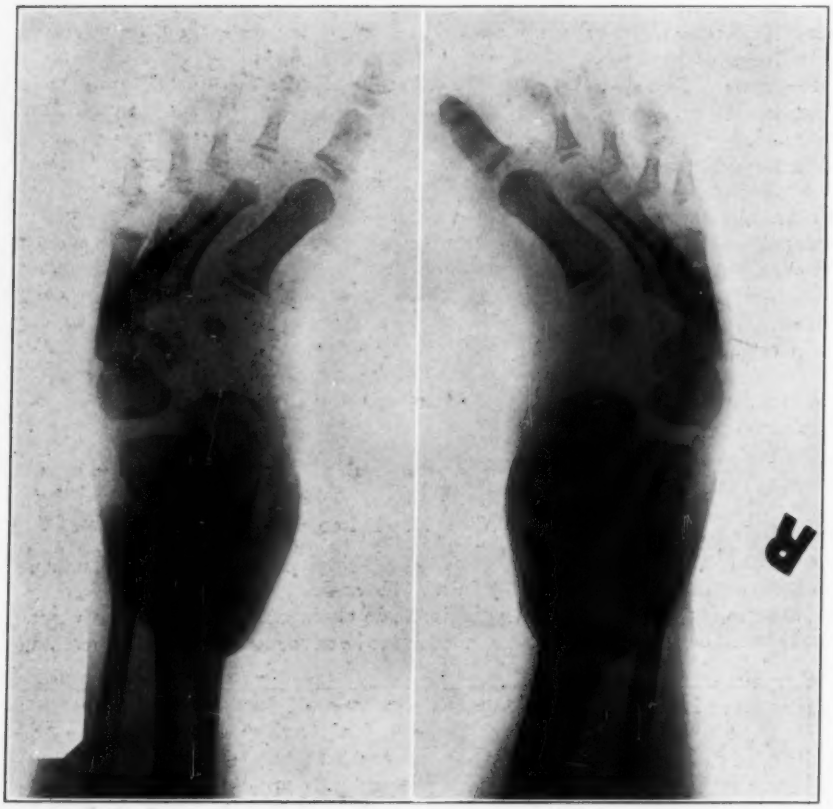

FIG. 9
Case 3. Robert R. Preoperative roentgenograms. See Fig. 10.

FIG. 10
Case 3. Robert R. Postoperative roentgenograms. Some correction obtained by exenteration of cuboid (Ogsten operation) and manipulation.

with the inner border raised from the floor save for the end of the big toe. A wide base was necessary to prevent interfering. While no knee valgus was present, gait seemed favorable for development of same. (Question of knee valgus of adult cases in early literature being secondary?) Roentgenograms obtained showed typical deformities as illustrated.

Open operation was performed by one of us (C. W. P.) on November 18, 1929, and the striking and suggestive tendon variation described in the preceding pages found in both feet. After transfer of tendon to cuneiform and capsulotomy of joint at base of first metatarsal, an oblique wedge-shaped resection was made through a separate incision of the bases of the other metatarsals, and the forefoot then manipulated, but with less overcorrection obtained than was hoped for. Complete reversal of deformity apparently necessitated reversal of the echelon-formation relations of the individual metatarsals and toes, which obviously would be resisted by the interosseus structures. After several casts a very symmetrical foot resulted on one side, but was not obtained on the other until a further wedge resection was done. The feet have been observed at intervals to date; they show normal function, normal shoe wear, and externally a nearly normal appearance; but late roentgenograms indicate imperfect skeletal relations, especially of the astragalus or posterior tarsus.

FIG. 11

Case 4. Betty G. Note relations of astragalus to calcaneous and mild grade of true metatarsus varus as indicated by slight curving of middle metatarsals.

CASE 2. Alice D., aged three and a half, (Children's Hospital of Michigan, No. 66606) registered August 29, 1929, with history of deformity noticed before walking began, but increasing with use. It was described as a turning in of the forefoot only, from the beginning (Fig. 6). No treatment had been given. On examination the feet

FIG. 12
Case 5. Bernice A. True metatarsus varus, moderate grade.

could be placed in contact with the floor throughout, but the rear part was in a position of marked pronation while the forefoot was both adducted and incurved to an extreme degree. X-ray showed typical high-grade distortions. On September 13, 1929, a capsulotomy (subcutaneous) was done at the base of the first metatarsal and the others were osteotomized subcutaneously. The ensuing manipulation did not accomplish the

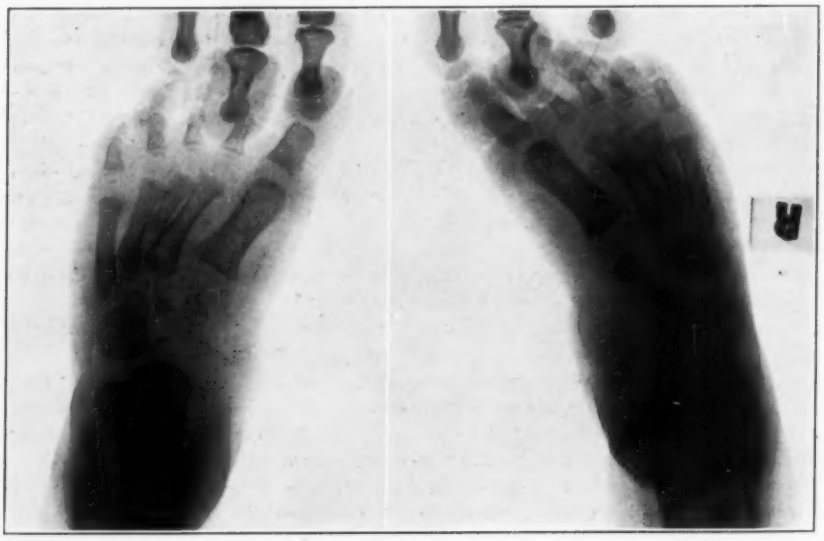

FIG. 13
Case 6. Margaret J. Very mild but true metatarsus varus.

desired degree of correction and on September 24 a subcutaneous osteotomy was done on the first metatarsal and on October 4 an open resection of the others. The result was a great improvement functionally and cosmetically, with normal use of shoes, and no complaint on last observation, May 3, 1931. X-rays continued to show characteristic skeletal deformity. Original roentgenograms have been lost and that of Figure 8 is the *final* one.

FIG. 14

Case 7. Francis V. Moderate true varus with ununited fracture of fifth metatarsal.

CASE 3. Robt. R. (Children's Hospital of Michigan, No. 64956) had history of deformity noticed in early months; no difficulty in walking on heels but apparently an increasing toeing-in. He was first observed June 25, 1929, with clinical findings similar to those in Case 1 and Case 2, but somewhat less in degree. X-rays showed typical distortion of moderately high grade. Molding plasters applied without much improvement. On May 16, 1930, a subperiosteal enucleation of the cuboid was done on each foot by one of us (C. W. P.) and the foot wrenched into apparently complete correction. Plasters were continued until July 14, 1930, when x-rays showed considerable diminution of deformity. On last observation feet were quite satisfactory (Figs. 9 and 10).

CASE 4. Betty G., aged four and a half, (Children's Hospital of Michigan, No. 49983) was first observed August 27, 1927, with history of deformity first apparent on walking (Fig. 11). Examination showed no equinus, but posterior tarsal valgus and metatarsus varus. Roentgenograms emphasized clinical findings with astragalus shown markedly displaced and rotated inward, and outer four metatarsals curved in their proximal thirds. On August 30, a subcutaneous fasciotomy and wrenching was done. No subsequent x-rays were obtained, but at the last observation, July 12, 1928, there was noted complete correction of metatarsal varus and considerable residual pronation.

CASE 5. Bernice A., aged two, (Children's Hospital of Michigan, No. 59545) was first observed on February 14, 1929, with history of bilateral foot deformity, first noted on walking. Examination showed no equinus or ankle varus, but marked metatarsus varus. X-rays demonstrated posterior valgus deformity and moderate curving of proximal portions of metatarsal bones and adduction of first (Fig. 12). Corrective plasters were applied but no subsequent observation obtained.

CASE 6. Margaret J., aged one and a half, (Children's Hospital of Michigan, No. 50957) was first observed October 8, 1927, with history of deformity only recently noticed in feet. Examination showed moderate metatarsus varus on left, more marked on right, no equinus. X-rays showed nearly normal posterior tarsal relations on left, and slight supination with outward rotation of astragalus on right, but with definite incurving of metatarsal bones on both sides (Fig. 13). Several manipulations and plasters were carried out with last observation on October 28 recording elimination of metatarsal varus but residual pronation. No additional x-ray examination was obtained.

CASE 7. Frances V., aged eight, (Children's Hospital of Michigan, No. 27056) was first observed on January 12, 1928, with history of intoeing deformity of left foot ever since beginning to walk. At that time was treated by local physician by application of cast;

FIG. 15-A

Case 8. Roentgenogram. Infant with true metatarsus varus, probably high-grade.

had worn outer sole wedge ever since. Six months previous had sustained injury to outer side of foot, with swelling and soreness ever since. Examination indicated marked metatarsus varus and some cavus. X-ray showed curved metatarsal bones and neutral relations in posterior foot (Fig. 14). In addition there seemed to be an ununited fracture in the fifth metatarsal with thickening and sclerosis of this bone. Wassermann test was negative. On January 27, 1928, a fasciotomy and wrenching was done, with last observation on February 2, 1929, recording a good result, but no x-ray check was made.

CASE 8. Baby F., aged six weeks, (Children's Hospital of Michigan, No. 82666) was first observed May 6, 1931, with story of inturning forefoot, bilateral, noticed since birth. On examination feet at first suggested congenital talipes equinovarus; but closer observation determined absence of equinus or ankle varus, but sharp metatarsal

FIG. 15-B

Case 8. Roentgenogram six months later. No treatment in the meantime.

FIG. 16
Case 9. Foster C. Typical adductus.

varus. X-rays emphasized this with the findings of markedly incurved metatarsals (Figs. 15-A and 15-B). In the original films the posterior tarsal relationship could be made out to be that of valgus or pronation. No further observation was obtained in this case.

CASE 9. Foster C., aged two, (Children's Hospital of Michigan, No. 53481) was

FIG. 17
Case 10. Typical adductus.

FIG. 18

Case 15. Wm. E. Primary right congenital talipes equinovarus with usual treatment, but residual findings resembling true metatarsus varus.

first observed February 9, 1928, with history of intoeing deformity, right, noted since birth. No previous treatment; never walked on ball of foot only. Examination showed no apparent deformity save metatarsal varus. X-ray showed marked pronation and inward rotation of astragalus on both sides, with considerable adduction deformity of metatarsus on right, but no incurving of individual bones (Fig. 16). No treatment was permitted. This case was classified as metatarsus adductus.

CASE 10. Junior R., aged two, (Children's Hospital of Michigan, No. 67355) was first observed on October 8, 1927, with story of deformity of right foot, first noticed on walking. Examination noted finding of pure metatarsal varus. X-ray indicated posterior tarsal valgus on both sides with sharp adduction of metatarsus on right, no curving of metatarsals (Fig. 17). A wrenching was done and plaster applied, with apparent improvement but no subsequent observation. Case classified as metatarsus adductus.

CASE 11. Mary L., aged two, (Children's Hospital of Michigan, No. 39469) was first observed on June 19, 1926, with story of deformity of right foot noticed on walking; no treatment. Examination notes described moderate varus deformity at metatarsus, no other variation. Treated by molding plaster with good result recorded on last observation, December 27, 1926. No x-rays obtained.

CASE 12. Billy E., aged six, (Children's Hospital of Michigan, No. 56071) was first observed on May 17, 1928, for intoeing deformity of right foot not previously treated. Examination findings note "typical metatarsus varus". No subsequent observation was made.

CASE 13. Vivian A., aged two, (Children's Hospital of Michigan, No. 61528) was observed on January 22, 1929, on account of intoeing of both feet, first noted on walking; no treatment. Examination notes indicated bilateral pronation and bilateral sharp metatarsus varus. No subsequent observation and no x-rays were obtained.

CASE 14. James S., aged seven, (Children's Hospital of Michigan, No. 63490) was observed on April 28, 1929, on account of intoeing deformity of right foot noted since birth. There had been no treatment. Boy had always been able to get heel down. Examination findings include tarsal valgus and metatarsal varus. No subsequent observation.

CASE 15. Wm. E., aged eight, private case, came for observation on account of persisting intoeing of right foot. Examination showed moderate metatarsal varus and tarsal valgus, x-rays showing considerable incurving of metatarsal bones, and the general picture of the primary congenital deformity being discussed. However, the history was very definite for a primary typical congenital talipes equinovarus for which treatment was initiated at three months and included successive molding plasters and final manipulation under anaesthesia. The case is reported to indicate that moderate typical metatarsus varus may be associated with, and residual from, ordinary congenital clubfoot, and, in classifying mild cases, the history of original deformity and treatment must be utilized to establish the propriety of diagnosis of primary congenital metatarsus varus.

SUMMARY AND CONCLUSIONS

A study has been made of the pathological character and, in most instances, of the response to treatment of fourteen cases of a congenital foot deformity, apparently to be recognized as a definite clinical entity, distinct from talipes equinovarus, yet one which is almost devoid of consideration in text and literature in the English language. The European Continental literature of the last twenty-five years was found to contain quite numerous references and case reports of this condition, including some of distinct value in the study and treatment thereof. Our analyses emphasize a dual nature of the skeletal deformity, and its marked resistance to complete correction. The general type of deformity may be properly subdivided into metatarsus adductus and metatarsus varus. In the former, satisfactory results can be expected from molding in plaster only. In the latter only milder grades are likely to respond to this technique, with the necessity of open intervention quite necessary for the more severe grades. In the latter, a muscle imbalance on a congenital basis may well be looked for, as illustrated by operative findings reported herein. The deformity is not well evaluated in most cases till after the first year and is more satisfactorily treated in ensuing years.

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PAGET'S OSTEITIS DEFORMANS IN RELATION TO CARDIOVASCULAR DISEASE *

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Clinical observations, coupled with the pathological findings in more than 900 autopsies convince me that Paget's osteitis deformans is the result of chronic cardiovascular disease. It is the outcome of long continued, intermittent high and low pressure, coupled with changes in organs of internal secretion so commonly accompanying cardiovascular disease. It is the result of the pathological, mechanical action of cardiovascular force long continued on tissues imprisoned by a dense encapsulated cortical bone and periosteum. This is encouraged by the internal secretions called on by bone changes already started by the trauma, minute but constant. The bone changes are more severe where the pituitary, thyroid, or parathyroid glands are independently diseased. It is only after years of bone changes that static conditions produce the more characteristic curves and deformities by which we clinically diagnose the disease.

Of 112 cardiovascular cases seen at autopsy, all show severe bone pathology. The changes in all are varying degrees of those seen in the three most affected, osteitis deformans.

The most marked cases are in three old men, two of whom had, during life, evidenced the alteration of bone structure by the typical bending and distortion of Paget's osteitis deformans, as the cases had been diagnosed. The bones evidence osteoporosis, widened coalescent haversian canals, osteogenesis, erratic architecture, passive congestion, oedema, hemorrhage, pigmentation, fibrosis, cellular hyperplasia, giant cells, clefts containing fluid and cells between lamellae, enlarged coalescent bone lacunae, and enlarged dividing bone cells, myxomatous, fatty, or very cellular marrow and cysts. These three cases of Paget's disease differ much in the amount and location of their alterations. In the same case the bones are variously changed and in different parts of the same bone the pathology varies. The amount of vascular change in the bones also varies greatly. One of the cases was not diagnosed Paget's osteitis deformans during life, but this man also had the bowing of bones and gave the microscopic picture of osteitis deformans. He came in with cardiovascular lesions and apoplexy.

The other 109 cases are in individuals varying in age from seventeen years to eighty years. Each had been the subject of cardiovascular disease for a long time. Disease of heart musculature is quite common, valvular disease most usual, and arteriosclerosis invariable.

The most striking change in the bones of these 109 cases is the passive congestion, oedema, widened coalescent haversian canals, and irregular, "erratic" architecture. This irregularity consists of increase in the number of haversian lamellar systems, unsystematically bounded, and with tortuous individual lamellae. The cortex is commonly narrowed. The

* From the Pathological Laboratory of the University of Maryland.

trabeculae show absorption by cells or fluid (vital). Their lamellae are widened and separated by fluid which often contains marrow cells. The marrow is cellular, with mostly large cells. These are often massed in areas. Not infrequently fibrosis of the marrow is seen. Osteofibrosis is not infrequent. Osteoblasts not uncommonly border trabeculae of the marrow and line the haversian canals. In the cases where there is a history of old syphilis or thyroid activity, there is invariably evidence of greater activity in bone production.

Some of the older cases are not to be distinguished from Paget's disease except by the lack of excessive architectural changes and greater amount of cell changes.

In examining the bone sections, the alterations are so striking that I label them "Like Paget's" and on looking up the clinical history find invariably that the history is of long-standing cardiovascular disease.

Looking through the description of Sir James Paget's cases, I find evidence of cardiovascular disease in most of them. His first case had severe arteriosclerosis, diseased mitral valves, and "the heart was thin-walled". One case was described as having vertigo and shortness of breath, and one died of valvular heart disease and Bright's disease. In one, the valves of the heart were found diseased. One had congestion of the brain for four years, one had "old syphilis", and another had old rheumatoid disease. Although Sir James in his Surgical Pathology refers to the specific action of the circulation in the disease of bone, and although his and Butlin's descriptions evidence severe vascular changes in the bones, he did not mention it as an etiological factor in osteitis deformans, but put it down as "a chronic inflammation of bone".

Many of the cases described in the literature were in persons with cardiovascular disease. Two of Hurwitz's cases were found in the "heart-case" wards. Syphilis and arteriosclerosis, often given as the cause of osteitis deformans, may be responsible through the attendant circulatory disturbances.

The pathology as seen in this generalized process has also been described by me and others as a localized lesion due to trauma.

It appears to me that leontiasis ossea, described in the literature as an independent entity or as an early manifestation of Paget's osteitis deformans, points to circulatory disturbance as the cause of the bone pathology.

We have the same bone changes localized or as a part of a generalized disease[8]. In three cases of brain tumor and in one case of chronic tuberculosis in my collection, I found leontiasis ossea. In these cases there was unusual passive congestion and oedema. That an infection could act as the initial trauma modifying the vascular pathology is not to be denied.

I described a case due to a gunshot wound at the upper extremity of the femur[3]. Sir James Paget referred to Czerny's case of localized osteitis deformans.

Many of the changes seen in these bones have been described by me in localized vascular pathology[5,6]. In "Activities of Bone Cells"[4] is given the circulatory pathology (chronic passive congestion, oedema, and

hemorrhage) a prominent part in the causation of their changes. I have referred to the part the circulatory system plays—both physical and cellular—in most of my writings on bone pathology. More recent observations have been reported by Horton[9], Ollonquist[10], J. J. Pemberton[11], and R. Pemberton[12].

The constant physical altered pressure, even though small, must act as a trauma to bone even more than to soft parts. Here, the mechanical effects of congestion are produced on inelastic tissue encased by a dense cortex and a periosteal sheath. One must not refer all the changes to physics. When once a tissue is altered there is a call on its attending internal secretion for its wants [7]. Not only this but, at autopsy on these cases, we commonly find alterations in glands (pituitary, thyroid, parathyroid, and ovaries) which influence bone physiology and pathology.

In my cardiovascular cases with old thyroid disease, there is noted a greater tendency to osteogenesis. It is noteworthy that where there is a syphilitic history, the tendency to osteogenesis is greater.

In 1908, writing of Bone Pathology in Its Relation to General Pathology[1], I described the changes in bone in a case not suspected of having heart disease. The diagnosis of a severe heart lesion was made after the microscopic changes in a metatarsal bone, removed for cosmetic reasons, led me to suspect cardiovascular disease, of which he died shortly thereafter. The passive congestion about tumors was considered as instrumental in the hyperplasia of bone in the neighborhood.

References to how local and general circulation change modifies bone are fully made in my various writings on bone. The most complete bibliography is to be found in "Ossifying Hematoma".[6]

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OSTEITIS TUBERCULOSA MULTIPLEX CYSTICA (JÜNGLING)

Report of a Case Involving the Larger Long Bones With Complete Proof of Its Tuberculous Etiology. A Review of the Literature * †

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In 1920 Jüngling reported his observations, begun in 1911, on a cystic condition of bone for which he claimed a tuberculous etiology and which he named at that time "Ostitis Tuberculosa Multiplex Cystica". In 1911 he first noted this affection, involving the phalanges and metacarpals of the hands, as well as the phalanges and metatarsals of the feet. From 1911 to 1919 four cases were observed by him and the following facts noted: the onset is gradual; pain may be present early but is not severe; there is marked cystic degeneration of the bone which is readily demonstrable by roentgenographic examination; there is a tendency for the small cysts to fuse, forming larger cysts; there is a lack of involvement of the periosteum and joints; there may be a lupoid involvement of the skin in the affected area; the histological picture shows epithelioid and lymphocytic cells, rarely giant cells, no caseation, and no tubercle bacilli; guinea-pig inoculation is frequently negative for tuberculosis and, when positive, is slow, requiring several months; the von Pirquet test is usually negative; the course of the disease is slow with a definite tendency toward spontaneous improvement and even recovery.

Until Jüngling's second article in 1928, the most important contribution on this subject had been that of Fleischner, who called attention to the frequent association of lupus pernio and Boeck's sarcoid with cystic changes in the bones analogous to the osteitis tuberculosa multiplex cystica of Jüngling, and attributed to both skin and bone lesions a common tuberculous origin.

Goeckerman assumes a common tuberculous etiology for lupus pernio and Boeck's sarcoid.

Valenti says: "This disease (lupus pernio and Boeck's sarcoid) becomes manifest with the presence on the skin of hemispheric elements varying in size from a small lentil to a small nut; their color is at first rosy, then pale, and in the end brownish; the consistency is soft and the surface is smooth and slightly squamous. Histologically the cutaneous nodules present the aspect of a chronic inflammatory process and consist of follicles with epithelioid cells, of lymphocytes and some giant cells." Kyrle has demonstrated the tubercle bacillus in microscopic sections of sarcoid lesions.

In 1927 Schürer-Waldheim reported one case of osteitis tuberculosa multiplex cystica, involving the fifth metacarpus and extending into the wrist joint.

* Received for publication May 23, 1932.
† Read before the Chicago Roentgen Society and the Chicago Orthopaedic Club, October 12, 1932.

In 1928 Jüngling published his second monograph. He reported nine cases which had been observed by him over a period of years. He again emphasizes the chronicity of the affection and the tendency toward spontaneous healing. He notes the frequent association of lupus pernio and Boeck's sarcoid. He emphasizes the frequent inability to demonstrate the tubercle bacillus in the tissues, and the difficulty of producing the tuberculous lesions in the guinea pig, and suggests that the tubercle bacillus causing this disease is one of extremely low virulence. He states that the same cystic condition may occur in the internal organs as in the bones, or that the cystic condition in the bones may be associated with typical tuberculous lesions of the internal organs.

In 1928 Mayr reported a case of lupus pernio with cystic changes in the phalanges. Of the fifty-two similar cases collected by him from the literature, forty were in men. He emphasizes, as does Jüngling, the absence of necrosis and sequestration (See Figure 1).

Also in 1928 Hecht reported two cases of osteitis tuberculosa multiplex cystica in the fingers. In one case lupus pernio developed several years after the bone changes were discovered.

In 1929 Casati reported three cases involving the phalanges.

In 1930 Schürer-Waldheim reported a case of osteitis tuberculosa multiplex cystica of the small bones of the hands and feet, associated with lupus pernio of the nose, in a man fifty years of age. The histological pictures of the nasal lesion and of an amputated finger were (with the exception of the bony structures) identical. Both showed many epithelioid cells; there were many giant cells, though fewer in the finger, resembling typical Langhan's giant cells. There was no caseation and no tubercle bacilli were found.

In our examination of the literature, dating from Jüngling's first article in 1920, we have found no instance of osteitis tuberculosa multiplex cystica (or "Cystoides" as Jüngling later called it) reported as occurring in the larger long bones, with the possible exception of Kienböck's work in which he describes similar cystic lesions in the tibiae and femora of children. He classifies these as "multiple cystic periostitis" and "epiphyseal-zone cystic osteomyelitis". His description of these conditions does not closely correspond to Jüngling's picture of osteitis tuberculosa multiplex cystica, nor does he claim that classification for either of them. He states that these lesions are benign, with a tendency toward spontaneous healing, and that they are probably tuberculous in nature, though he offers no proof of this contention.

Such a case, however, has come under our observation which we feel, because of its rarity and because of our definite etiological findings, should be added to the literature.

Mr. H. L. G., aged thirty-two, married, white, native American, a carpenter, served as a mechanic with the American Army in France. He was first seen by one of us * on

* Van Alstyne.

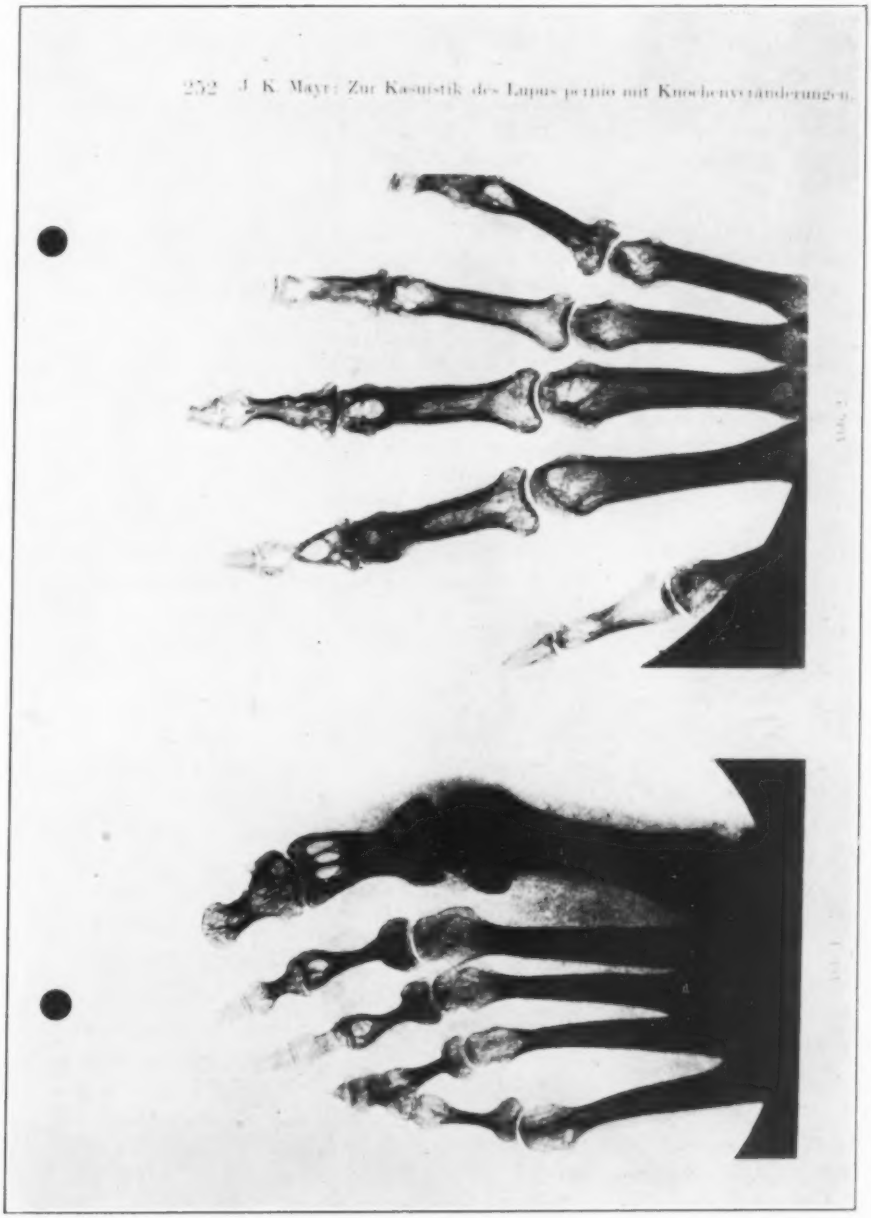

FIG. 1

This cut is reproduced from J. K. Mayr's article: "Zur Kasuistik des Lupus Pernio mit Knochenveränderungen" in *Archiv für Dermatologie und Syphilis* (CLV, 248, 1928), by the kind permission of the publisher, Julius Springer, Berlin.

This roentgenogram is typical of the lesions reported by the other authors mentioned in this report.

April 7, 1931, at which time he complained of (1) swelling and slight pain in the region of the left elbow with limited motion in the joint, and (2) aching and limited motion in the right shoulder.

Clinical Course:

Seven years before (1924) he fell four feet, striking his left elbow on a window sill. He continued working, though the elbow felt sore for four or five days. Two months later he ran a splinter of wood into the palm of the left hand near the wrist. This gave no trouble at the time or later; he mentioned that he believed there was still a small piece present. (This is mentioned here as it was considered later as a possible portal of entry of coccidioidal infection suggested by Dr. Dick in his roentgenological report.) Two years later (1926) he bumped the same elbow; while playing cards he swung around and struck his "crazy bone" on a chair. The elbow was lame for two or three days following this slight injury. One year later (1927) he noticed a difficulty in extending the left elbow and pain on motion, also an aching in the elbow, especially at night. It would "limber up" and feel all right while at work during the day. He consulted a doctor who had an x-ray taken (Fig. 2), diagnosed the condition "neuritis", and treated it with "violet ray" for one month without benefit. A few months later he saw another doctor who made a diagnosis of "occupational rheumatism and neuritis".

The following year (1928) he consulted Dr. Frank D. Moore * who ordered an x-ray from which he made the diagnosis of "bone cyst near upper joint of left ulna". (This x-ray film is missing from the records.) Dr. Moore operated at the Garfield Park Hospital on May 23, 1928. His operative record reads: "Incision on the posterior lateral as-

* Deceased.

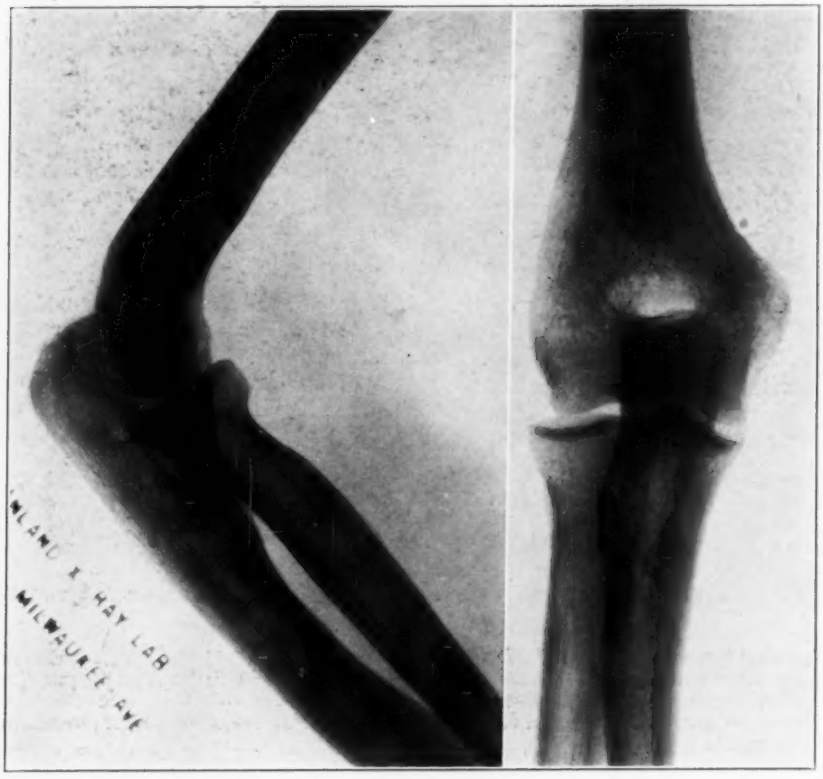

FIG. 2

pect of forearm, upper third; cyst emptied; adhesions broken up, wound closed in layers. Postoperative diagnosis: same." This wound was closed without drainage and healed promptly. After this he was free from pain and lacked only about ten degrees of complete extension at the elbow.

One year later (1929) soft nodules appeared deep in the tissues over the inner condyle of the humerus. He experienced no pain at this time. He again consulted Dr. Moore who had another x-ray taken (Fig. 3). His diagnosis was "bone cyst", and operation was performed on July 10, 1929. The following is taken from the records of the Garfield Park Hospital: "Preoperative diagnosis: bone cyst. Operation: Opened and curetted; closed without drainage. Pathological report (signed by Dr. Paul Schmitt, Pathologist): Periosteal infection, low-grade. No acid-fast bacilli or other micro-organisms were found. A differential count of the cells present shows lymphocytes eighty-six per cent., polymorphonuclear neutrophils fourteen per cent. Microscopic sections of formalin-hardened material show a necrotic tissue. A diagnosis cannot be made, but a tuberculous process should be ruled out by further study (tissue section and guinea-pig inoculation)". Again the incision healed kindly.

In April 1931, when examined, he stated that for the past nine months he had noticed a slowly increasing swelling under the scar of the second incision which was over the

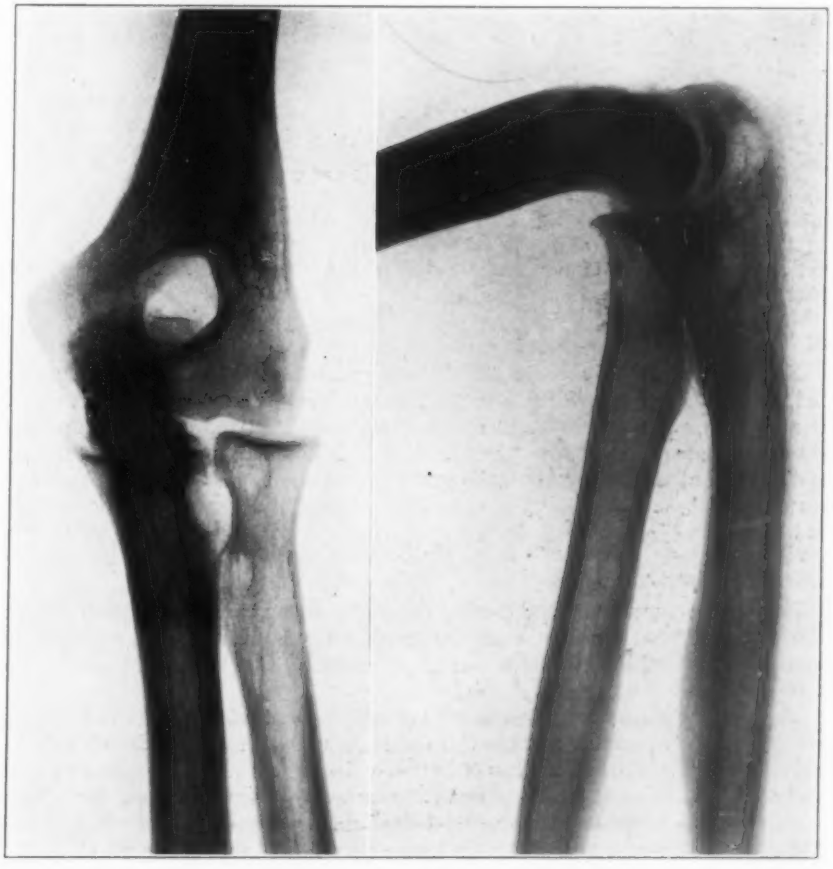

FIG. 3

FIG. 4

lower and mesial aspect of the inner condyle of the left humerus. It was only very slightly tender to touch.

Past Illnesses:

He was "gassed" in France in 1918, following which he was blind for three days, spit blood, coughed incessantly for two weeks, and was hospitalized for about three weeks under a diagnosis of "bronchitis and a touch of flu". In 1921 and 1922 he suffered with night sweats, loss of weight, was "nervous", and felt feverish at night. A heart lesion was diagnosed at this time. Until the past few years he had always had a heavy depressed feeling back of his breast bone on damp days. There was no further relevant past history.

Physical Examination:

Patient was a well nourished, healthy-appearing young man of about thirty years. The eyes, nose, throat (tonsils absent), ears, neck, lungs, heart, abdomen, and lower extremities were essentially negative. The deep and superficial reflexes were normal. The temperature was normal.

The positive findings were: limited motion in the right shoulder,—the entire shoulder girdle moved freely on the thorax but there was not more than five degrees of motion in the shoulder joint. There was a loss of forty-five degrees of full extension and an equal loss of complete flexion at the left elbow. Two scars of former operations near the left elbow were visible,—one along the upper end of the ulna, and the other on the mesial aspect of the elbow extending upward over the internal condyle of the humerus. Under this second scar was a smooth, rounded, fluctuating, cyst-like tumor, seemingly just beneath

FIG. 5

the skin, about three centimeters in diameter. It was only very slightly tender. Just above it a more elongated and firmer mass could be palpated, situated deeper in the tissues under the triceps. This was about one by three centimeters, and was suggestive of a lymph gland. There was no oedema, redness, or other sign of acute inflammation present in this region. There was a firm body about three-tenths of a centimeter long and the width of a toothpick at the base of his left palm which could well be a small piece of wood splinter located just under the skin. There was no tenderness nor inflammation about it.

Preoperative Laboratory Findings:

Blood counts and urine analysis were normal. Blood serum Wassermann and Kahn precipitation tests were negative. A von Pirquet test was faintly positive. Roentgenograms were taken by the National Pathological Laboratory and interpreted by Dr. Paul G. Dick (Figs. 4 and 5). "The shadows representing the bones forming the left elbow present the following departures from normal: in the lower end of the humerus and upper portion of the radius and ulna there are several irregularly rounded shadows of decreased bone density. These do not have the usual transparencies of cysts. The outer portion of the humerus at its articular margin is roughened, and there is evidence of bone destruction in this area which apparently is localized. There is evidence of bone regeneration at the outer margins of the head of the radius and outer lip of the coronoid process of the ulna. There is narrowing of the articulation suggesting destruction of the interarticular cartilage. Just distal to the tip of the olecranon process there are areas of calcification which apparently are in the joint capsule. Shadow densities in the soft tissues are noted

FIG. 6-A

Section of lining membrane of "bone cyst" showing coagulation necrosis with outer layer coat of epithelioid and giant cells.

FIG. 6-B

Higher magnification of same, with round, epithelioid, and giant cells in wall of bone cyst.

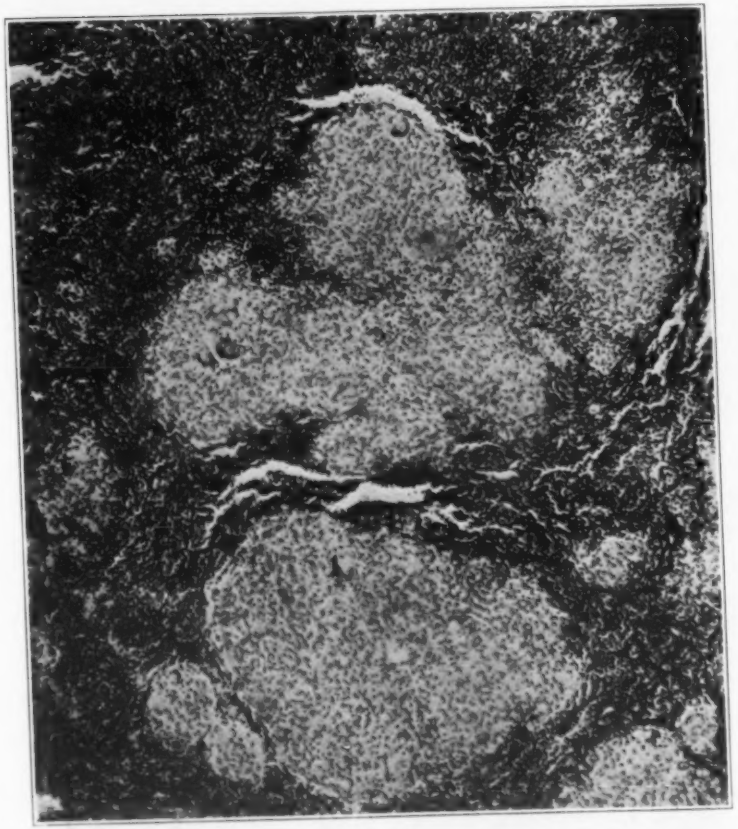

FIG. 7

Lymph gland adjacent to affected elbow, containing typical epithelioid tubercles, with many giant cells.

FIG. 8

Section of guinea pig's lymph gland inoculated with fluid from "bone cyst". Note the epithelioid tubercles and giant cells.

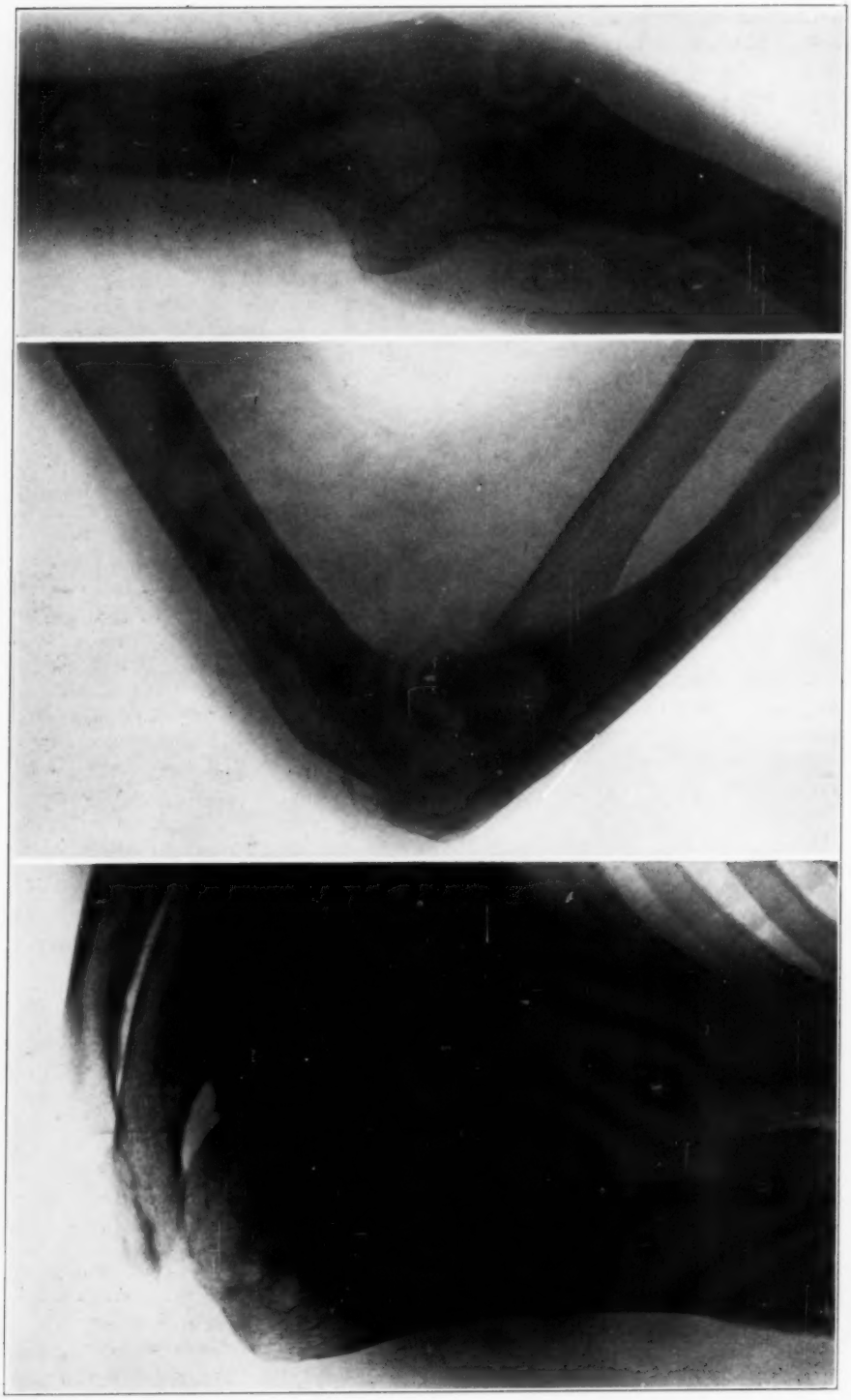

FIG. 9

internal to the head of the radius and external to the condyle of the humerus. There is some periosteal hyperplasia of the lower end of the shaft of the humerus.

"The above described changes do not have the usual features of an osteofibrosis cystica. The periosteal thickening and osteophytic deposits near the articular edges suggest a low-grade inflammatory change. The rounded areas of decreased density could be atypical cyst formation. The possibility of this being a luetic infection is also to be considered. Another condition to be considered is coccidioidal granuloma, if history should indicate this patient to have visited Southern California or other of the southwestern states. This is suggested on account of the soft-tissue changes that are demonstrated. There is no evidence of malignancy.

"In the head of the right humerus there are a number of irregular small areas of decreased bone density which are apparently surrounded by a definite wall and apparently there is no breaking down of the bones surrounding these small areas. They have the appearance of cysts and are quite similar to the condition found in the region of the left elbow. There appears to be destruction of the interarticular cartilage with some roughening of the articulation but there is no evidence of ankylosis. There is no expansion of the cortex. The x-ray evidence would point to a benign condition. There are none of the characteristics of malignancy present. There is no periosteal hyperplasia. The x-ray features, being similar to the shadows in the region of the left elbow, would indicate this condition to be of the same origin."

Fluoroscopic examination and stereoscopic roentgenograms were made of the chest. Dr. Dick's report follows: "The shadows representing both lung fields are apparently clear. There is no evidence of old or recent pulmonary tuberculosis seen in either lung field. In the right lower lung there is a single shadow density which is probably an old focus of infection which is now healed, but I doubt very much whether this is of tuberculous origin. The hilum and intermediate shadows are within normal limits. The pleural margins are clear throughout. There is no evidence of old or recent pleurisy. The size, shape, and position of the heart and aorta conform to the normal. The superior mediastinum is clear."

Dr. W. H. Watterson has made an independent interpretation of these chest films. I quote from his letter: "Stereo study of plate dated April 17, 1931, taken by the National Pathological Laboratory, Chicago, Illinois, No. 37332, shows no evidence of gross pathology in either lung. There is, however, definite evidence of primary foci of Ghon in the right base and careful study reveals that there are densities leading from this on up to the right hilum, in all probability due to the same primary infection, and leaving faint densities, probably fibrous in type, along the root zone of this lung."

In addition, x-rays were taken and reported by Dr. Dick of all of the remaining bones of the patient's body (excepting the skull). These were all entirely negative.

Operation:

The patient entered Wesley Memorial Hospital on April 14, 1931, and was operated upon the following day under nitrous-oxid anaesthesia for removal of the cyst of the left elbow for further diagnosis. An incision was made over the cyst and an attempt was made to enucleate it from muscle and fascia. This was successful for a distance, but, there being no definite line of cleavage, the cyst eventually ruptured and a quantity of yellowish, thinly gelatinous material was evacuated. The cyst wall was then found to be continuous with a fibrous-like lining of the cavity which appeared in the x-ray in the region of the olecranon fossa. This membrane was thoroughly curetted away and a compact bony wall found underlying, which was in no sense necrotic. No soft nor necrotic bone came away with the curette. The wound was closed without drainage and healed promptly. The regional lymph gland mentioned was then enucleated. The cystic sac, its contents, the curettings, and the lymph gland were carefully preserved for cultural and microscopic examination. A guinea pig was inoculated with the semifluid contents of the cyst.

Postoperative Pathological Reports:

"*Macroscopic:* This specimen consists of two large remnants of a cyst wall; one is

wedge-shaped, three by two centimeters and three to four millimeters thick, of irregular shape, both of which are composed of bluish-gray to brown fibrous-like tissue with occasional nodules of yellowish fat. There are two masses of 'hazel-nut' sized semigelatinous white tissue and also several 'pea-sized' brownish-gray, friable, fairly firm masses of tissue, in the centers of some of which are firm white nodules.

"*Microscopic:* (1) The cyst wall consists of a chronic granulation tissue containing a few giant cells of the Langhan's type. In places typical tubercles are also present (Figs. 6-A and 6-B). (2) The lymph node is thickly studded with tubercles in which the epithelioid cells are strikingly seen. But little caseation is evident (Fig. 7). Diagnosis: (1) Tuberculosis of bone cyst lining membrane; (2) Regional tuberculous lymphadenitis." (*S. Vaughan, Pathologist for Wesley Memorial Hospital.*)

These sections were also examined by Dr. Bowman C. Crowell, of the American College of Surgeons, Dr. Ludwig Hektoen and Dr. J. J. Moore, of the National Pathological Laboratory; and Dr. J. P. Simonds, of Northwestern University Medical School; all of whom were agreed on the diagnosis of tuberculosis, and also that there was no evidence of a coccidioidal infection.

Report on guinea pig: "Inoculated April 15, 1931; autopsy on May 28, 1931. (1) Direct smears from lymph nodes stained by Ziehl-Neelsen method show many acid-fast bacilli morphologically identical with tubercle bacilli. (2) Microscopic sections of guinea-pig tissues confirm the diagnosis of tuberculosis." (See Figure 8.)

On October 7, 1931, following a day or two of slight pain in the region of the elbow, a small bleb appeared on the most recent scar, similar in appearance to the ordinary "stitch abscess", though lacking any signs of acute inflammation. On opening this bleb a small quantity of a caseous-like material was exuded. A small probe was passed into this opening which proved to be a sinus leading into the cystic cavity in the bone,—the one we had entered at operation. A smear was made of this material with the following report: "The smear shows a moderate number of leukocytes and lymphocytes and a rare acid-fast bacillus, morphologically identical with the tubercle bacillus". (*R. Getty, Bacteriologist, Wesley Memorial Hospital.*)

Treatment:

Jüngling suggests no definite line of treatment, other than symptomatic; he mentions that wedge-like excisions of the cystic parts may be of value, but does not report having tried this procedure. We consulted Dr. Paul Magnuson for advice as to treatment. He suggested immobilization of both affected regions. This suggestion was followed and the patient's right shoulder and left elbow were immobilized in light aluminum splints until December 1, 1931. The splints were then removed, since by that time practically complete ankylosis had taken place in both joints.

Later Course:

The general condition of the patient remains satisfactory; he has gained eight pounds in weight; has been fever-free; eats well, and sleeps well. Occasionally he has a neuritic type of pain in the regions of these joints, never persistent nor severe. Early in October, 1931, he complained of neuritic pain in his left wrist and fingers. Roentgenograms were taken at that time which proved negative. The pain persisted only a few days. At the same time x-rays were retaken of the right shoulder and the left elbow, which show no increase in the cystic condition and still show no bone destruction. On the other hand they seem to show some regression as the cystic cavities appear denser than in the earlier pictures. This would conform to the findings of Jüngling and others of spontaneous improvement (Fig. 9).

Prognosis:

We find no mention in the literature of any case with a fatal termination; instead we find frequent mention of spontaneous improvement and even recovery. If our patient has not improved since coming under our observation he has, at least, not retrogressed. In the light of our present information we are hoping for an eventual recovery.

CONCLUSIONS

We feel justified, from the history and findings here presented, in placing this case under Jüngling's classification of osteitis tuberculosa multiplex cystica.

We have found no report in the literature of this disease occurring in the larger long bones.

Previous authors have based their claim for a tuberculous etiology on few positive findings or even on indirect evidence. We have been able to fully establish positive proof of its tuberculous nature by: (1) microscopic tubercles in the cyst wall and in a regional lymph gland; (2) tubercle bacilli in the cyst content; (3) microscopic tubercles in the tissues of a guinea pig six weeks after inoculation; (4) tubercle bacilli in the inoculated guinea pig's lymph nodes; with (5) a positive von Pirquet test, (6) marked chronicity from the start, and (7) a very possible preexisting pulmonary tuberculosis.

We wish to express our gratitude and appreciation to the Garfield Park Hospital for furnishing its records; to Dr. Crowell, Dr. Hektoen, Dr. Simonds, Dr. J. J. Moore, and Dr. Watterson for their charitable consultations; to *Archiv für Dermatologie und Syphilis* for kind permission to reproduce Dr. J. K. Mayr's x-ray plates, and especially to Dr. Paul G. Dick for his enthusiastic interest in this case, his many helpful suggestions, and for a series of gratuitous roentgenographic examinations.

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FRACTURE OF THE CAPITELLUM AND TROCHLEA, COMBINED WITH FRACTURE OF THE EXTERNAL HUMERAL CONDYLE

BY ROBERT C. ROBERTSON, A.B., M.D., AND FRANKLIN B. BOGART, M.S., M.D.,
CHATTANOOGA, TENNESSEE

Intra-articular fractures of the distal end of the humerus are uncommon. Lindem [1] reviewed the literature in 1922 and found only seventeen cases of fracture of the capitellum, of the trochlea, or of both. They were produced by one of two mechanisms,—a blow on the upper part of the dorsum of the partially flexed forearm, transmitting the force through the articular end of the ulna and the head of the radius to the capitellum and trochlea; or a fall on the hand with the elbow extended, the force being transmitted through the long axis of the radius and ulna to the capitellum and trochlea. When both capitellum and trochlea were involved, they were separated from the humerus *en masse*. Excision of the fragment was given as the treatment of choice. When not reduced or excised, the fragment united to the distal end of the humerus with marked functional disturbance.

Lindem reported three additional cases of fracture of the capitellum and trochlea. In two the etiology was a fall on the hand with the elbow extended; in the other, a fall striking on the posterior surface of the flexed elbow. The cases were seen two, five, and six months, respectively, following fracture. In all, flexion was slight, pronation and supination were normal. In two cases the fragment was freed from the humerus and excised. In one case this resulted in slight improvement after five months; in the other, motion was doubled and pain was absent eight days after operation. The third patient refused operation and was not followed. Fracture through the external condyle was not mentioned by him.

Additional reports of fracture of the capitellum have since appeared.

Eliason, Goldsmith, and Pendergrass in their text [2] show the roentgenogram of a fracture of the capitellum and trochlea.

Homma and Pape [3] first described fractures of the capitellum and trochlea combined with fracture of the external condyle. Two cases were reported by them. The etiology in both was a fall on the flexed elbow. In one, a fracture of the internal epicondyle was also present; in the other, the ulna was displaced laterally on the humerus. The major fragment (capitellum and trochlea) was excised in both cases, with good functional results.

We feel that fractures of this type constitute a distinct clinical entity, and that their apparent rarity warrants the report of additional cases.

CASE 1. S. W. A., Jr., white, student, seventeen years of age. Twelve hours previous to examination on May 30, 1930, while roller-skating, he fell on the extended

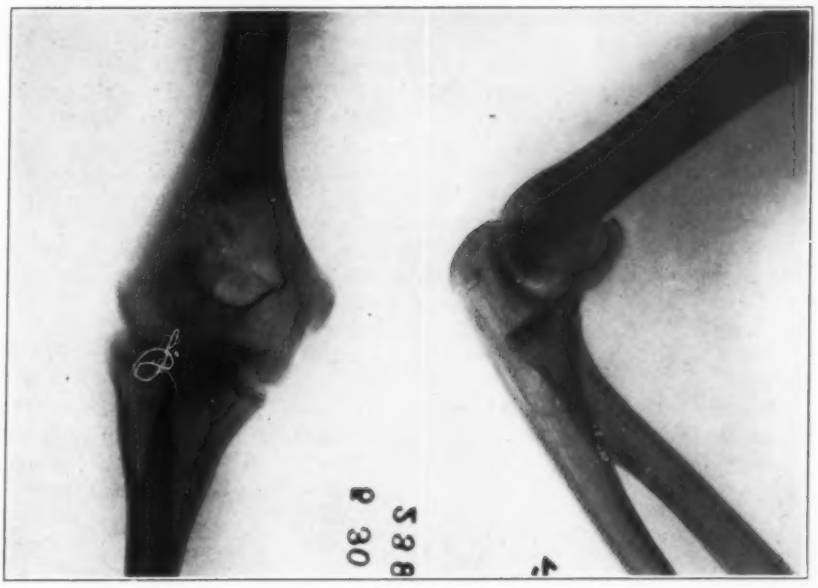

FIG. 1

Case 1. Prior to reduction (May 30, 1930).

left hand with the elbow in hyperextension. There was immediate pain and disability in the elbow, which had grown progressively more marked.

The left elbow was carried in seventy-five degrees' flexion, with forearm midway between pronation and supination. There was moderate swelling of the entire joint area

FIG. 2

Case 1. Nineteen months after reduction (December 14, 1931).

without other gross deformity. Flexion and extension were limited to about fifteen degrees, and were painful. Pronation and supination were quite free. No gross displacement or bony masses were palpable. Crepitus was not obtained.

A lateral roentgenogram revealed a vertical fracture extending through the capitellum and trochlea, with slight upward and forward displacement of the fragment. An anterior-posterior plate confirmed the upward displacement of the major fragment, and revealed an oblique line of fracture extending through the external condyle into the joint, with very slight lateral displacement. Fusion was incomplete in the epiphyses of the medial epicondyle, the radial head, and the olecranon.

With nitrous oxid anaesthesia, reduction was easily obtained under the fluoroscope by gentle hyperextension, accompanied by downward digital pressure in the cubital space, followed by full flexion and fixation in Jones's position. Active motion was instituted on the tenth day; a short sling was applied on the sixteenth; and light weight carrying began on the twenty-ninth. Normal range of painless motion was present two months following injury.

The patient was last seen on December 14, 1931. The injured elbow could not be identified on physical examination. There had been no pain or other disability. Roentgenograms on this date showed a normal relation between all the bony structures which help to form the elbow joint. The fractures were firmly united and there was no excess of callus.

Case 2. R. S., white, male, farmer, seventeen years of age, was examined on July 3, 1930. While running through the woods two days previously he fell on the extended left hand with the elbow in extension. There was immediate pain and disability in the elbow, soon followed by swelling. Manipulation with ether anaesthesia under the fluoroscope by another surgeon, about eight hours following the accident, and again on the following day, had not reduced the fracture. The patient was then referred for treatment.

The entire elbow area, forearm, and hand were markedly swollen and oedematous. The elbow was held in 100 degrees' flexion by an adhesive strip. Flexion and extension were limited to about fifteen degrees. Pronation and supination were present through an arc of thirty degrees. Dorsiflexion of the wrist was absent. There was no other evidence of nerve lesion. No gross displacement or bony masses were palpable. No crepitus was obtained.

Fig. 3

Case 2. Prior to attempted reduction (July 3, 1930).

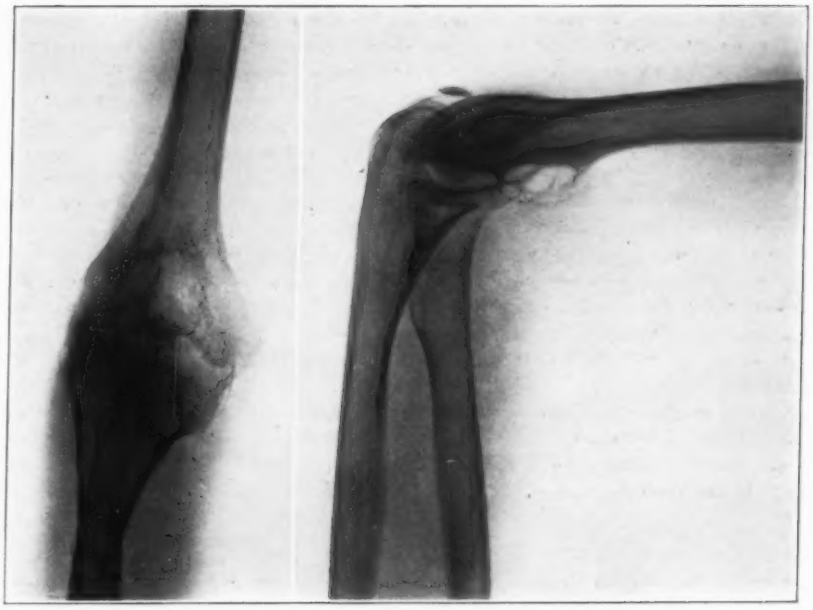

FIG. 4

Case 2. Twenty months after failure of closed reduction (March 1, 1932).

A lateral roentgenogram revealed a vertical line of fracture separating the capitellum and trochlea from the humerus, with marked upward and slight forward displacement of this fragment. There were two small fragments immediately distal to the olecranon. The epiphyses of the olecranon and the radial head were not completely fused. On anteroposterior view the upward displacement of the major fragment was confirmed, and an oblique fracture of the external condyle extending into the joint, with slight outward and downward displacement of the fragment, was seen. The epiphysis of the internal epicondyle was not completely fused. Comparison with the original plates showed that the attempts made at reduction on the previous days had displaced the anterior fragment farther upward.

Under ether anaesthesia, reduction under the fluoroscope was attempted by gentle hyperextension combined with downward digital pressure in the cubital space, followed by flexion. This was unsuccessful. On hyperextending the elbow, the lateral edge of the fragment could be replaced, but the balance of the fragment resisted reduction, its bony axis being obliquely displaced upward and medially.

Excision of the fragment was advised and refused. A molded plaster splint was applied with the elbow in seventy-five degrees' flexion. The patient left the hospital two days later and refused to return for observation until March 1, 1932, on which date he stated that he had removed the plaster splint "about a week" after leaving the hospital. He complained of pain only on active use of the extremity.

The entire extremity was moderately atrophic. The elbow was carried in eighty degrees' flexion, with the forearm in pronation. No nerve or circulatory disturbance was present. Active flexion-extension and pronation-supination were limited to ten degrees. All motion was accompanied by slight crepitus. A firm mass was palpable in the cubital space.

Roentgen examination revealed a mass of callus in the cubital space which had been thrown down at the site of the old fracture of the capitellum and trochlea with a marked deformity in the articulating surface. This callus in the cubital space had a cystic appearance.

Excision of the bone mass was advised and refused.

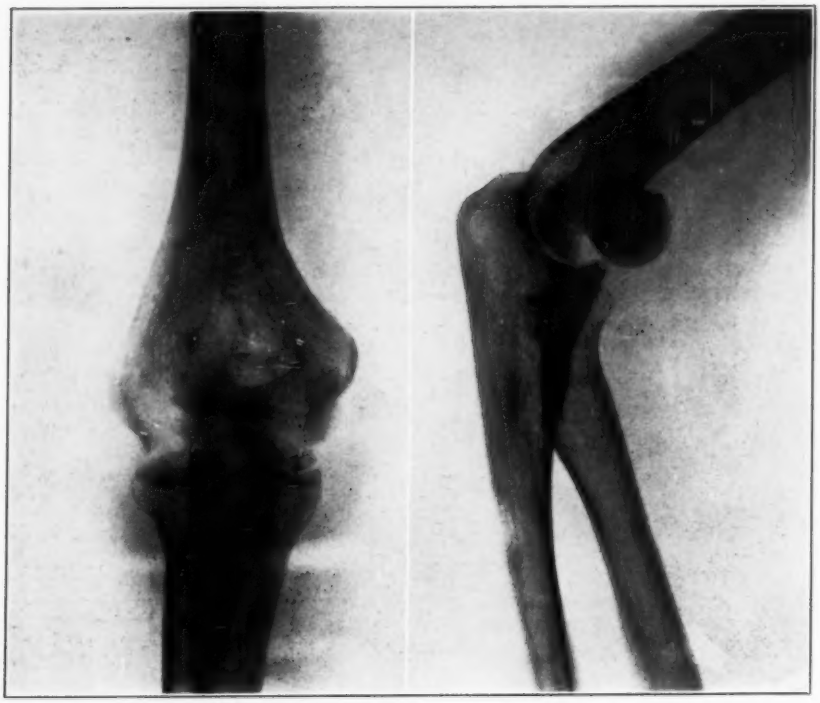

FIG. 5

Case 3. Prior to reduction (April 17, 1931).

CASE 3. Mrs. W. H., white, housewife, twenty-four years of age. On April 17, 1931, while crossing a street, she fell forward on the outstretched hands with both elbows in extension. There was immediate severe pain and disability in the right elbow. This was treated by home remedies until April 21 when a physician was consulted, who, after roentgen examination, attempted reduction under the fluoroscope with ether anaesthesia. This was unsuccessful. She was referred on the following day.

The elbow was carried in a sling in ninety degrees' flexion, with forearm midway between pronation and supination. There was slight periarticular swelling. Flexion and extension were limited to thirty degrees. Pronation and supination were slightly limited. No masses were palpable. No crepitus was obtained.

Roentgenograms revealed on lateral view a vertical fracture through the capitellum and trochlea with marked upward displacement of the anterior fragment. Comparison with the previous plates revealed this displacement to be less than prior to manipulation on the previous day. On anteroposterior view, upward displacement of this fragment was seen, as well as an oblique fracture through the external condyle, extending into the joint, with slight downward displacement of the lateral fragment. Under ether anaesthesia, reduction was easily accomplished under the fluoroscope by gentle hyperextension accompanied by downward digital pressure in the cubital space, followed by acute flexion and fixation in Jones's position. Active motion was started on the tenth day; a sling was applied on the twenty-first day and continued for three weeks. Three weeks after discarding the sling the range of flexion was 80—135 degrees, with full supination and pronation. Daily diathermy, massage, and supervised active motion were instituted at this time with increase of ten degrees in flexion-extension after ten days' time. No further improvement was obtained in the following three weeks, at the end of which time

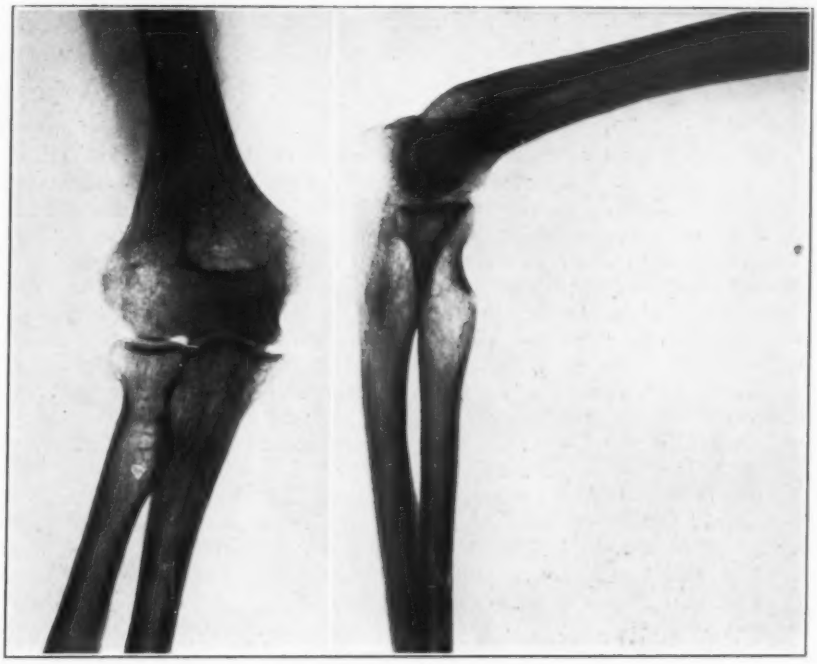

FIG. 6

Case 3. Eight months after reduction (December 12, 1931).

the joint was gently manipulated under general anaesthesia. This resulted in no improvement and was repeated one month later.

Patient was not seen again until four and one-half months after the second manipulation (eight months following reduction). At this time the range of active flexion was 30—135 degrees. Pronation and supination were normal. There was no complaint of pain. Roentgen examination at this time revealed complete healing of the fractures in good position. There was a small mass of callus two by three millimeters at the edge of the joint between the capitellum and the head of the radius.

In an attempt to ascertain the relative frequency of this type of fracture the plates of all elbows x-rayed for possible fracture at Baroness Erlanger Hospital during the period, January, 1922 to April, 1932, and in the private laboratory of one of us (F. B. B.) during the period, March, 1930 to April, 1932, were reviewed with the following findings:

Total number of cases roentgenographed	721
Negative for fracture	315
Plates showing fracture	406

Of this number there were:

Fracture of radial head	181
Fracture of proximal end of ulna	46
Fracture of distal end of humerus (including above reported cases)	179

No additional cases of vertical fracture of the capitellum and trochlea, combined with fracture of the external condyle, were found. Fractures similar in type were as follows:

A. Mrs. L. C., forty-six years of age. Vertical fracture of the capitellum, and fracture through the external condyle with slight upward displacement of both fragments. Etiology not of record. Refused treatment, surgeon in charge unable to follow.

B. Mr. G. R. W., sixteen years of age. Vertical fracture of capitellum and small adjoining portion of trochlea with marked upward displacement of this fragment. Vertical fracture through major portion of trochlea without displacement. Linear fracture through external condyle without displacement. The epiphyses of the radial head, the internal epicondyle, and the olecranon were incompletely fused. Etiology: fall on hand with the elbow in extension. Closed reduction was unsuccessful in our hands, when attempted twelve days after injury. The displaced fragment was removed by one of us (R. C. R.) four days later. Full supination and pronation, but only ten degrees' flexion and extension were obtained.

C. Miss T. D., twenty-four years of age. Vertical fracture of the capitellum and a portion of the trochlea with rotation of the fragment, the articular surface pointing upward. The lateral margin of the radial head (constituting about one-fourth of the circumference of the head) was detached and displaced downward. This fracture resulted from a fall on the extended hand with the elbow in extension. Refused treatment, surgeon in charge unable to follow.

DISCUSSION

Vertical fracture of the capitellum and trochlea, combined with fracture of the external humeral condyle, occurred three times in a total of 406 cases of elbow fracture reviewed by us, a percentage of seventy-three one-hundredths.

The etiology in our cases did not apparently differ from that which may produce fracture of the head of the radius, the coronoid process, the capitellum, or the external condyle, or anterior dislocation of the elbow. In children the same mechanism may produce supracondylar fracture or epiphyseal separation. We feel that the exact mechanism of this type of fracture is uncertain.

Although two of our cases had been subjected to manipulation prior to our examination, the striking features in all were: (*a*) the generalized periarticular swelling without other deformity; (*b*) freedom of pronation and supination; (*c*) limitation of flexion and extension; (*d*) absence of crepitus, and (*e*) absence of pain on pressure over the radial head. No masses were palpable in the cubital fossa.

Diagnosis was correctly made only by the x-ray.

On roentgen examination, minor fragments were displaced posteriorly in one case. These fragments were small, and apparently detached by the line of fracture extending through the external condyle.

Closed reduction was easily accomplished in two cases. In both it was followed by proven bony union in good position, and good functional results. No difficulty was experienced in maintaining position following reduction. We feel that closed reduction should be attempted in all recent cases of this type, and that in case of failure early excision of the displaced fragment is indicated.

Early active motion does not appear to be contra-indicated.

CONCLUSIONS

1. Vertical fracture of the capitellum and trochlea *en masse*, combined with oblique fracture of the external condyle, exists as a distinct though uncommon type of elbow fracture.

2. This fracture may be produced by falls on the hand with the elbow extended.

3. Bony union in good position, with good functional results, followed closed reduction in two of our three cases.

We wish to express our appreciation to Dr. Edwin L. Jenkins, Soddy, Tennessee. Without his cooperation, the late examination of Case 2 could not have been obtained.

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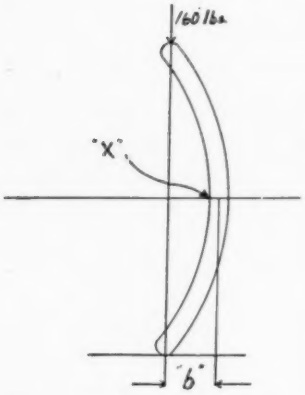
STRESSES IN A CURVED COLUMN

BY FREMONT A. CHANDLER, M.D., CHICAGO, ILLINOIS



The following table, showing the stresses in a curved column, may be of interest in its application to deformity of the bones of the lower extremities or in malunion of fractures. This table was prepared by an engineer, himself suffering from Paget's disease, and has specific application to an average-sized tibia with bowing. These are purely engineering figures having to do with a vertical load on a column and, of course, do not take into consideration the influence of muscles, ligaments, etc.

A column of round cross section, one and one-half inches in diameter, sixteen inches long, with the ends pivoted (that is, free to turn) carries a load of 160 pounds. The stress of various offsets are shown below:

Offset "*b*" *In inches*	Maximum Stress at "*X*" *Comparison in pounds per square inch*	Percentage of Maximum Stress Compared to Straight-Column Stress
0 (Straight Column)	130	100
¼	339	261
½	548	422
¾	757	582
1	966	743
1¼	1175	904
1½	1384	1065
1¾	1593	1225
2	1802	1386
2¼	2011	1547
2½	2220	1708
2¾	2429	1868
3	2638	2029
3¼	2847	2190
3½	3056	2351

You will note that the straight column shows a stress at "*X*" of 130 pounds per square inch, which was given at 100 per cent. The table then shows the stresses and the percentage of increased stresses for each increment of one-quarter-inch offset. Mathematically it works out that the increase in stress is directly proportional to the offset, so that, with as slight an offset as one-half inch from the straight line, the stress in the case of a man weighing 160 pounds amounts to 548 pounds per square inch, or 422 per cent. as compared with the percentage of 100 for a straight column.

THE STABILITY OF THE HIP FOLLOWING WHITMAN'S RECONSTRUCTION OPERATION

BY ALBERTO INCLAN, M.D., HAVANA, CUBA

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The object in publishing the following cases is to present clinical proof of the stability of a reconstructed hip in which the Whitman method has been employed. A criticism very often made of Whitman's reconstruction operation for non-union with atrophy of the neck of the femur is the tendency toward the luxation of the femoral diaphysis when the limb is brought into adduction. This accident has happened in but one of the writer's cases, and was not due to the operation itself, but to the fact that the postoperative plaster spica holding the limb in full abduction was broken and the leg attained adduction in consequence.

When the trochanter is transplanted at least two inches downward from its normal position, and full abduction is maintained until the trochanter is united to the femoral diaphysis, there is very little possibility of luxation. Two cases in this series of reconstructed hips, using Whitman's technique, have demonstrated the stability of the reconstructed hip. In each case a fall, occurring some time after the operation, resulted in a fracture of the femur, without affecting the area of operation.

The first case may be considered as the worst type for the successful outcome of the above mentioned operation, due to the fact that the

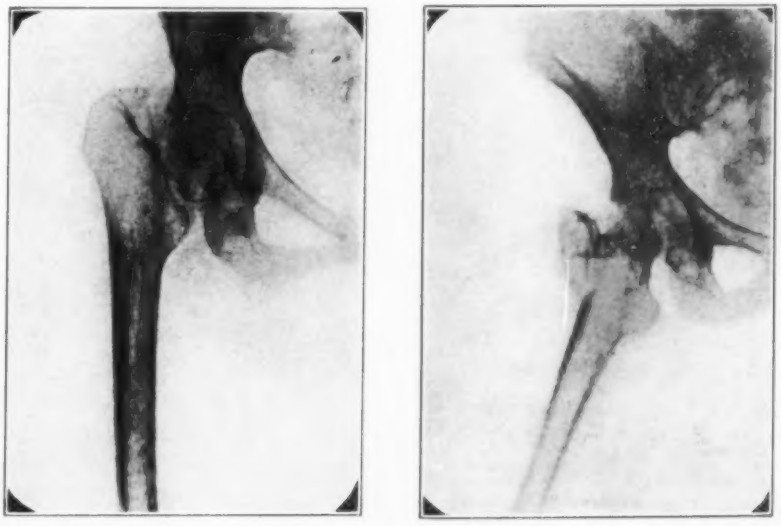

FIG. 1

Original condition and postoperative result following Whitman's reconstruction of the hip. (Courtesy of *Anales de Cirugia.*)

patient was suffering from a hemiplegia on the affected side, and was operated on eleven months after the neck of the femur had been fractured. In the meantime the limb had been maintained in adduction, flexion, and inward rotation, tenotomies being necessary to correct the deformity and to bring the limb into full abduction at the time of the operation. This patient, while walking with the aid of crutches, two months after leaving the hospital, fell and sustained a supracondylar fracture of the femur. The roentgenographic examination showed that the femur was held in place in the acetabulum in spite of the trauma. Although this patient has never returned for a final examination, and the functional result cannot be reported, we are mentioning it as a proof of the stability of the reconstructed hip.

The second case has been followed more thoroughly and a full report is possible.

CASE 2. C. J., female, white, fifty-eight years of age, was first seen at the Hospital Mercedes on October 4, 1929, ten months after a fracture of the neck of the left femur. There was at that time non-union with partial absorption of the neck of the femur, atrophy of the head, and marked rarefaction of the trabeculae of the femoral diaphysis, shortening of two inches, trochanter well above Nelaton's line, inability to raise the heel from the bed, and complete functional disability,—marked oedema of knee joint with motion of twenty-five degrees. The general condition was fair,—blood pressure normal, no sign of organic disturbance, Wassermann negative.

FIG. 2

Spinal fracture of the femur. Anteroposterior view.

FIG. 3

Spiral fracture of the femur. Lateral view.

Operation, November 20, 1929. Regional anaesthesia, epidural and sacral, was used. Whitman's technique was followed and the trochanter was transplanted at least two inches down the femoral diaphysis; there was slight postoperative shock. Immobilization was maintained for forty-five days; the wound healed by first intention. Postoperative roentgenogram shows good union of the trochanter, and the femoral end well maintained in the acetabulum.

After a long period of physiotherapy the patient was able to leave the hospital in September 1930, walking with a cane, without pain, but with flexion at the knee limited to about twenty-five degrees. On

FIG. 4

Osteosynthesis with Putti-Parham bands. Reconstructed hip not disturbed.

FIG. 5

Limb in adduction; solid union; marked adaptational changes at the reconstructed joint.

FIG. 6

Limb in abduction, showing leverage obtained after transplantation of trochanter.

November 19, 1930, while walking in her room without the aid of her cane, the patient fell and was unconscious, and, being alone, had no assistance until she recovered consciousness, when she found it impossible to get up. Later she was taken to the hospital. Clinical and roentgenographic examination showed complete spiral fracture of the upper third of the left femur, with three fragments, and with marked displacement and overlapping, but the area of the reconstruction operation, performed just a year before, had not been disturbed.

On account of the line of fracture, the existing displacement, and the difficulty of controlling the intermediate triangular fragment, an open reduction and synthesis were done under spinal anaesthesia on November 26, 1930. Two Putti-Parham bands were used for fixation. Immobilization was maintained in a Thomas splint for six weeks, followed by massage and physiotherapy; walking with crutches was allowed until April 23, when the patient was able to walk with the aid of a cane and was discharged from the hospital.

Present condition (May 15, 1932). The patient walks without a cane when performing her household duties, but uses a cane on the street as a precautionary measure, and requires assistance only in fastening the high extension shoe which is worn to compensate for the two inches' shortening resulting from the reconstruction operation. The hip is painless with sufficient active mobility in all directions; the left knee still shows limitation of flexion to forty-five degrees and clinical signs of chronic arthritis. The roentgenographic examination showed marked functional adaptation of the articular surfaces of the reconstructed hip and solid union maintained at the site of the fracture.

In conclusion, it may be added that this case, in which the line of fracture clearly demonstrates the acting forces of torsion and flexion necessary to produce this type of spiral fracture of the femur, and in which the reconstructed joint was submitted to a very severe test, proves satisfactorily the stability obtained by the operation previously performed.

LENGTHENING OF THE FEMUR WITH SIMULTANEOUS CORRECTION OF COXA VARA

BY SYLVAN L. HAAS, M.D., SAN FRANCISCO, CALIFORNIA

From the Shriners' Hospital for Crippled Children, San Francisco

The amount of shortening of the extremity in coxa vara is dependent on the degree of upward displacement of the shaft on the neck of the femur. The loss in length in the ordinary type of coxa vara usually does not exceed one inch, but in cases associated with other influencing factors—as anterior poliomyelitis, malunited fractures, or destructive lesions of the femur—the disparity in length may be much greater.

The restoration of the normal angle of the neck to the shaft is usually accomplished by an osteotomy in the subtrochanteric region of the femur. With the correction of the deformity some lengthening is obtained, but with the various types of osteotomies that have been advocated not more than one-half to three-quarters of an inch gain in length of the femur has been attained. In those patients where there is a shortening of several inches, some other supplementary bone-lengthening operation must be instituted. It appeared probable that if a long intertrochanteric osteotomy was performed and at the same time traction applied in the right direction, the coxa vara could be corrected and lengthening of the femur accomplished at the same time. With this object in view, the following procedure was carried out on two patients.

PROCEDURE

An incision is made from the greater trochanter downward for about twenty centimeters on the anterior lateral surface of the thigh. The greater trochanter is exposed by peeling back the insertion of the muscles, after which dissection is carried down so as to expose the anterior surface of the shaft to below the level of the lesser trochanter. A long diagonal osteotomy is then outlined, extending from the tip of the greater trochanter downward and inward to below the lesser trochanter. A sharp broad osteotome is used to perform the osteotomy so planned, care being exercised to make sure that the fragments are free. Thus is produced what is really an intertrochanteric fracture with the head, neck, and part of the intertrochanteric region making up the proximal fragment, and the remainder of the femur the distal fragment. By applying the principle usually instituted in the treatment of this type of fracture—namely, traction in abduction and flexion—the angle of the neck can be corrected and the lower fragment pulled down on the proximal to give additional length to the femur. Skeletal traction by means of a pin inserted into the lower end of the femur or upper end of the tibia is necessary to get a sufficiently strong pull to obtain the required increase in length. A brief

résumé of two cases will serve to present some of the details of the procedure and its application.

PATIENT 1. Male, aged thirteen years.

History: At the age of three years the patient sustained a fracture of the right femur in the subtrochanteric region. A pseudarthrosis, which was unsuccessfully treated by several operations, existed at the time of his admission to the Shriners' Hospital.

Examination: There was a pseudarthrosis in the subtrochanteric region of the right femur with coxa vara and about five and one-half inches of shortening (Fig. 1).

Treatment: September 8, 1930. Resection of the bone at the site of the pseudarthrosis and implantation of a tibial bone graft. Successful result obtained (Fig. 2).

Second operation: January 29, 1932. Resection of one and one-half inches from the normal femur (Fig. 4, left).

Third operation: April 9, 1932. Lengthening of the femur and correction of coxa vara. The operation as previously outlined was performed. In Figure 3 can be seen the line of osteotomy. Skeletal traction was obtained by passing a pin through the tibia and fastening cable wires from the pin to the end of a Thomas splint. Direct pull was made on the splint in abduction and flexion with the necessary weights up to thirty-five pounds for the first week. The foot of the bed was raised, using the weight of the patient for countertraction. The weight was decreased to twenty-five pounds during the second week and to fifteen pounds for the third week. At the end of the

FIG. 1

Patient 1. Non-union of nine years' duration with coxa vara. The right leg is five and one-half inches shorter than the left.

FIG. 2

Patient 1. Union of pseudarthrosis after nine years' duration following resection and bone graft. Coxa vara and shortening of five and one-half inches still present.

third week adhesive plaster skin traction was substituted for skeletal traction for four weeks. A plaster spica was then applied for two weeks and, after its removal, exercises in bed were prescribed. The patient was allowed to be up on crutches as soon as his strength permitted, with gradually increasing amounts of weight-bearing on the injured extremity.

Result: The coxa vara of the neck of the femur was fairly well corrected and from one and one-half to one and three-quarters inches of lengthening obtained (Fig. 4, right). This increase in length in conjunction with the shortening of the good leg has reduced the disparity in length from five and one-half inches to about one and three-quarters inches at present.

FIG. 3

Patient 1. Shows intertrochanteric osteotomy of femur. Traction was applied after the osteotomy. Note the restoration of the normal angle of the neck with the shaft and pulling down of distal fragment of the femur.

FIG. 4

Patient 1. Final result. Note correction of coxa vara. Length increase of about one and three-quarters inches obtained. Note opposite femur in which there has been a resection of a portion of the shaft to shorten the femur and help equalize the two extremities.

FIG. 5

Patient 2. Coxa vara with two and one-half inches of shortening before operation.

PATIENT 2. Male, aged thirteen years and three months.

History: This boy had anterior poliomyelitis at the age of three years, with resultant permanent paralysis of the left extremity.

Examination: The left limb is about two and one-half inches shorter than the right and there is a marked coxa vara of the femur (Fig. 5).

Treatment: April 27, 1932 an intertrochanteric diagonal osteotomy of the femur was performed as outlined (Fig. 6). A pin was driven through the remainder of the greater trochanter on the proximal fragment to the side of the ilium to fix it in position. A second pin was then driven through the lower end of the femur for skeletal traction which was applied in abduction and flexion for thirty days by means of a Thomas splint similar to that used in the first case. The skeletal traction was supplanted by skin traction for one week, after which a plaster spica was applied to the left extremity until union was complete.

Result: The coxa vara was corrected and, at the same time, two and one-half inches in length obtained (Fig. 7).

COMMENTS

By the method described it is possible to lengthen the femur and correct the coxa vara at the same time. Although some increase in length is obtained by the correction of the coxa vara, the greater amount is due to the excursion of the distal fragment downward on the proximal fragment.

The correction of the angle between the neck and shaft can be controlled by varying the abduction and flexion of the distal fragment, checking as necessary by roentgenograms.

The tendency for early union is similar to that which takes place routinely in intertrochanteric fractures. Some hesitancy was felt in the first case where there had existed a non-union for nine years in the operative area. Union, however, proceeded without delay.

Skeletal traction may be applied by a pin through the lower end of the femur or upper end of the tibia, the latter being less likely to cause disturbances in the knee joint if the duration of traction is not over four weeks.

This method of lengthening is applicable in securing lengthening even when there is no coexisting coxa vara. The operative procedure is relatively simple and no special apparatus is necessary.

FIG. 6

Patient 2. Showing intertrochanteric osteotomy with pulling down of the distal fragment. Note change in angle of neck.

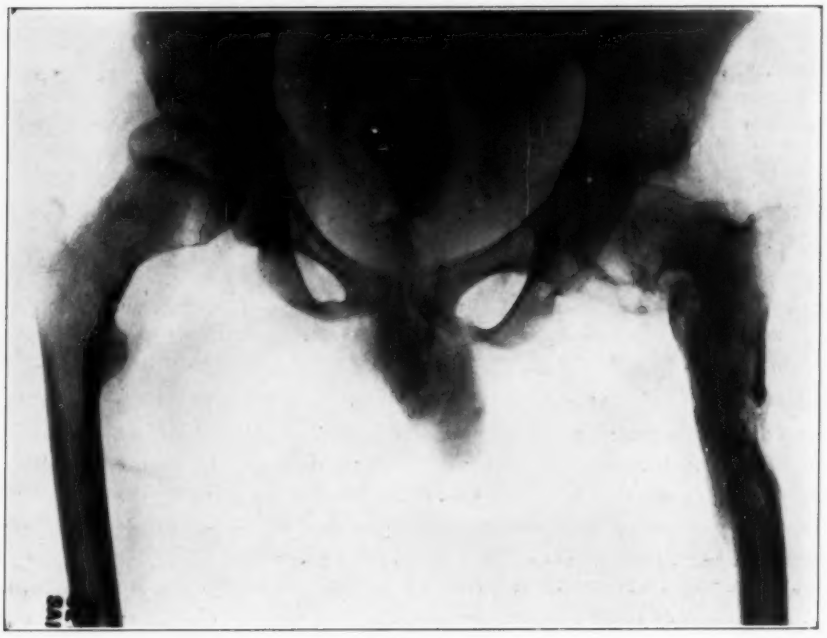

FIG. 7

Patient 2. Final result. Note the correction of coxa vara. In this patient, beside correction of coxa vara, two and one-half inches' increase of length was obtained by this procedure.

CONCLUSION

Lengthening of the femur and correction of coxa vara can be simultaneously obtained by making a diagonal osteotomy from the greater to the lesser trochanter and applying skeletal traction to the distal fragment. The correction of the coxa vara can be regulated by the degree of the angle of abduction and flexion. Some of the lengthening is dependent upon the correction of the coxa vara but the greater amount is due to the downward excursion of the distal fragment on the proximal fragment.

OSTEOCHONDRITIS OF THE INTERNAL CUNEIFORM*

BY JOSEPH BUCHMAN, B.S., M.D., F.A.C.S., BROOKLYN, NEW YORK

In a recent article [1] the author called attention to the fact that since 1888 a number of writers have described a group of conditions, all of which have more recently been grouped under the generic term of osteochondritis, signifying a non-inflammatory derangement of the normal process of bony growth occurring at the various centers of ossification at the time of their greatest developmental activity. He then listed the various locations in which these affections were found,—namely, the centrum and the superior and inferior epiphyseal regions of the vertebral bodies, the sternal end of the clavicle, the acromion, the coracoid process of the scapula, the head of the humerus, the internal epicondyle of the humerus, the olecranon, the heads of the metacarpal bones, the iliac crests, the pubic bones, the ischial tuberosity, the capital epiphysis of the femur, the epiphyseal cartilage between the head and neck of the femur, the greater and lesser trochanters of the femur, the patella, the upper and lower ends of the tibia, the tibial tubercle, the lower end of the fibula, the astragalus, the apophysis of the os calcis, the base of the fifth metatarsal, the heads of the second and third metatarsal bones, and the sesamoids of the big toe. Since the writing of the above-mentioned article, other foci of this disturbance have been described in the literature. These are the acetabulum [6], the lower end of the ulna [7], and the accessory tarsal scaphoid [8]. The purpose of this communication is to present two case reports of still another site, which, to all appearances, has not as yet been described,—namely, an involvement of the internal cuneiform associated with a similar affection of the tarsal scaphoid.

CASE REPORTS

CASE 1. The patient, a white male, six and a half years old, was seen in the summer of 1930, complaining of pain in the left foot subsequent to a twist of the foot as a result of a misstep. Examination revealed that the general physical status of the child was essentially negative, save that he walked with a limp on the left side. Locally, there was tenderness on the dorsum of the foot in the region of the internal cuneiform. There was no ecchymosis, redness, local heat, or oedema.

Roentgenographic examination of the left foot (Fig. 1) revealed that the internal cuneiform was definitely deformed and much smaller than normal, especially in its longitudinal axis. Its inner two-thirds presented areas of rarefaction and condensation and its outlines were smooth but irregular. The scaphoid was markedly underdeveloped, as is evident from a comparison with a roentgenogram of a normal foot of a child of the same age and sex (Fig. 2), and presented two centers of ossification arranged in a vertical alignment, the dorsal being smaller than the plantar segment. In the dorsoventral view three centers of ossification were visible. The texture of these centers showed areas of apparent rarefaction and condensation. No pathological changes were noted in any of

* From the Services of Dr. Samuel Kleinberg, Hospital for Joint Diseases, New York, and the United Israel Zion Hospital, Brooklyn, New York; and the First Orthopaedic Division, Hospital for the Ruptured and Crippled, New York.

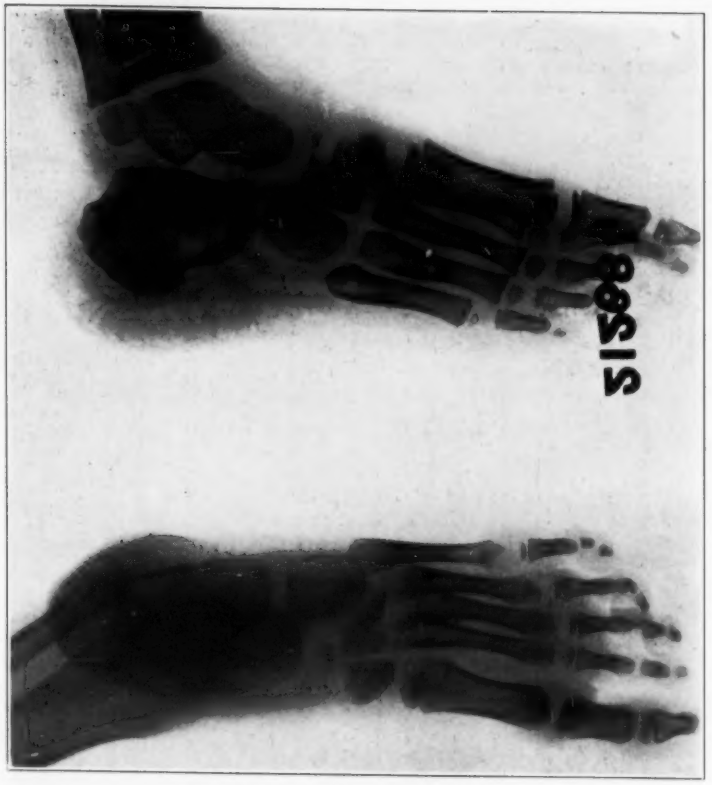

FIG. 1

Case 1. Anteroposterior and lateral views of the left foot, showing the irregularly shaped internal cuneiform, its lessened longitudinal diameter, with areas of condensation and rarefaction. The scaphoid is markedly underdeveloped, and consists of three ossific centers, which present irregularities of calcification.

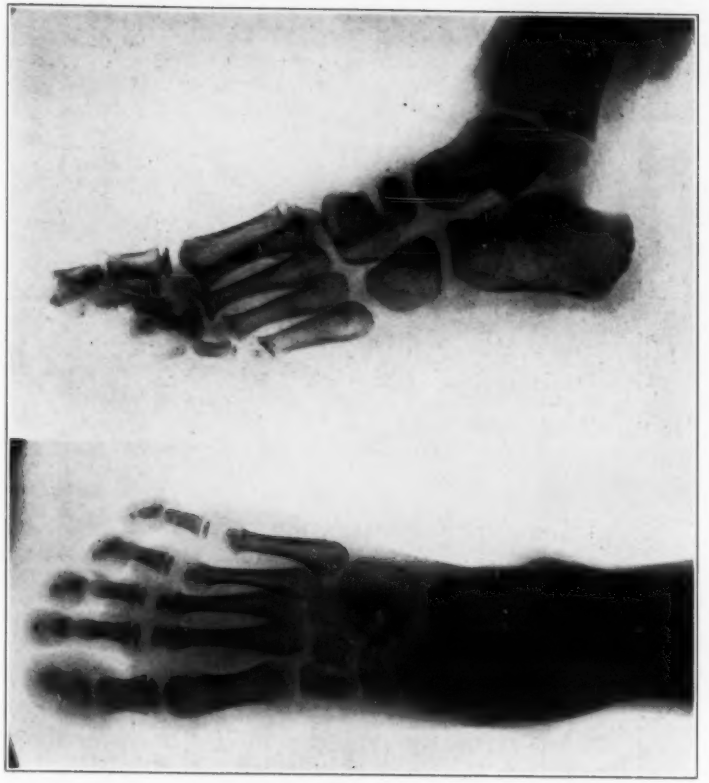

FIG. 2

Roentgenogram of a normal foot of a boy, six and a half years old, for comparison with Figs. 1 and 3.

present irregularities of calcification.

FIG. 3

Case 1. Roentgenogram of the patient's right foot showing a similar appearance of the internal cuneiform. The scaphoid presents two centers of ossification but no areas of rarefaction or condensation.

FIG. 4

Case 1. Anteroposterior and lateral views of the left foot twenty-six months after Fig. 1, showing a diminution in the longitudinal diameter of the scaphoid and of the internal cuneiform. The former still presents changes in calcification, while the latter presents a normal structure. The outline of the scaphoid is irregular.

the other tarsal bones. Roentgenographic examination of the right foot (Fig. 3) revealed identical changes, with the exception that the scaphoid did not show any changes in calcification, although it presented two centers of ossification.

The patient was treated with adhesive strapping for two weeks and was relieved of his pain. Two years later, the patient was recalled and questioning elicited that the interval history was negative save for the observation by the parents that the child walked with his feet turned out. Physical examination at that time was negative, save for a moderate grade of double weak feet.

A roentgenographic study made twenty-six months subsequent to the previous examination (Fig. 4)—that is, at the age of eight years and eight months—showed that the internal cuneiform is somewhat compressed in its longitudinal diameter. Its structure, however, is practically normal. The scaphoid is also compressed in its longitudinal diameter, and presents several areas of rarefaction and condensation. It is also noted that the outline of the scaphoid is irregular. Examination of the right foot (Fig. 5) shows a similar condition, with the exception that the rarefaction and condensation in the scaphoid is not quite so marked.

CASE 2. The patient, a colored male, six and a half years old, was admitted to the Out-Patient Department of the Hospital for Joint Diseases because of a fracture of the forearm. He had no complaint referable to his feet. Physical examination was negative, save for the local condition in the forearm. He had in addition a mild grade of double weak feet. His right foot was roentgenographed for purposes of comparison with that of Case 1. Much to our surprise, we found a roentgenographic appearance (Fig. 7) similar to that in Case 1. Both the scaphoid and the internal cuneiform presented irregularities in calcification and outline, while their longitudinal diameters were slightly diminished. The patient was lost from sight and a roentgenographic study of the left foot could, therefore, not be made, much to our regret.

COMMENT

A consideration of the clinical and roentgenographic findings in the first patient makes it very evident that we are dealing with an instance of the so called osteochondritis of the internal cuneiform of both feet, associated with an alteration in the scaphoid consisting of multiple nuclei of ossification, underdevelopment, and later changes in morphology suggestive of the end result of Köhler's disease. The mild clinical history referable to the left foot, the lack of clinical manifestations of any disturbance in the right foot, the marked roentgenographic changes, the association with the classic disturbance of the scaphoid, the subsequent course and the practically complete reformation of the affected bones, leave little doubt as to the character of the lesions. The second case is very definitely one of osteochondritis of the scaphoid, as shown by the roentgenographic study; the appearance of the cuneiform is so similar that the same diagnosis—namely, osteochondritis—seems reasonable and correct.

A review of the literature on ossification of the internal cuneiform shows that according to Gray, Piersol, Bailey and Miller, and Kreuscher, the center of ossification appears during the third year. Spalteholz notes its appearance during the first year of life. Cohn states that ossification begins at three and one half years of life, while Haret, Dariaux, and Quénu list its appearance at one and one-half to two and one-half years of life. Piersol also notes that very exceptionally the cuneiform

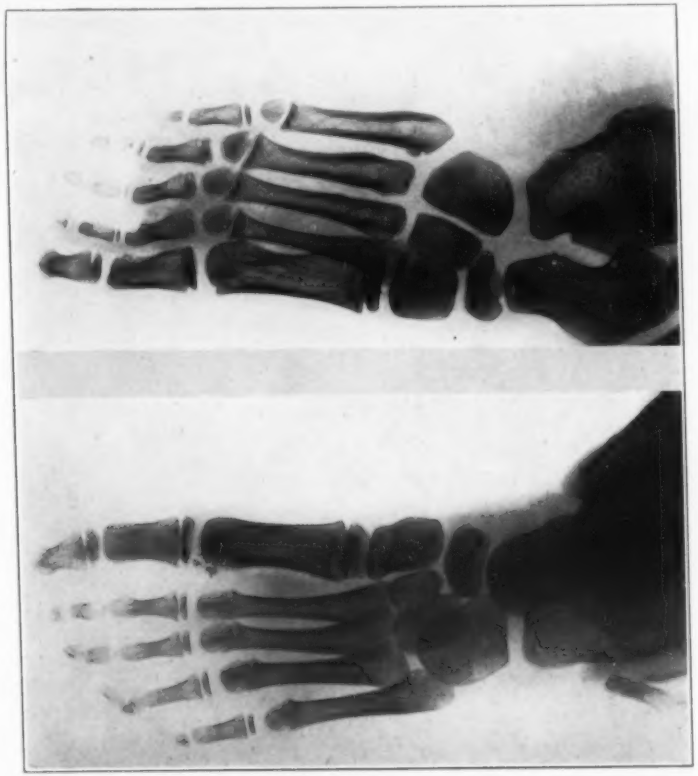

FIG. 5

Case 1. Anteroposterior and lateral views of the right foot twenty-six months after Fig. 3, showing the reduction in the longitudinal diameter of the internal cuneiform and the scaphoid, the irregular outline of the scaphoid, and the normal calcification of these bones.

FIG. 6

Roentgenogram of a normal foot of a boy, eight and a half years old, for a comparison with Figs. 4 and 5.

FIG. 7

Case 2. Anteroposterior and lateral views showing the lessened longitudinal diameter of the scaphoid and internal cuneiform with irregularities of outline and areas of condensation and rarefaction.

presents two ossific centers, and the bone may be divided by a suture into two, a dorsal and plantar.

The consensus of opinion is, therefore, that ossification begins at about three years of age. Immediately thereafter there is an unusually rapid growth to bring this ossific center to a size that is normally considerably larger than that of the second cuneiform which, according to the same authorities, begins to ossify at three or four years of age. There is, therefore, at this age a state of great developmental activity which brings with it a physiological weakness incidental to the rapid growth, thus making it a favorable site for the development of an osteochondritic disturbance.

The center of ossification for the scaphoid appears, according to Gray, and Bailey and Miller, at four years of age. Piersol and Spalteholz

place its time of appearance at four to five years of age, while Cohn notes it at three and one-half to four, and Haret, Dariaux and Quénu at two and one-half to three and one-half years of age. None of these authors makes mention of multiple centers of ossification, except Haret, Dariaux and Quénu who speak of a "*pointe interne*" at four to five and one-half years of age. It seems, therefore, justifiable to assume that the multiple areas of ossification noted in our case is not a normal variation. Furthermore, the subsequent appearance of both scaphoids, the areas of irregular ossification, their irregular outlines, and subnormal size all speak in favor of the belief that these bones were also subject to osteochondritic changes. A comparison of Figures 4 and 5 with Figure 6, which is a roentgenogram of a normal foot of a male child of the same age as that shown in the former figures, will make the above described changes very evident.

A detailed discussion of the etiology of this condition will not be entered into in this brief presentation, for this matter has already been discussed in detail in previous communications [1, 2, 3, 4]. Suffice it to say, however, that in all probability it is due to an imbalance of stress and strain imposed upon a physiologically weakened area. This imbalance may be due to an increased stress and strain, resulting from an abnormal weight or excessive activity, or it may be due to a diminished resistance incidental to rapid growth. The latter is probably the factor in these particular instances.

CONCLUSION

This communication deals with two cases presenting three instances of a hitherto undescribed and apparently rare focus of osteochondritic derangement of the internal cuneiform associated with a similar involvement of the tarsal scaphoid. The subsequent history of the first patient revealed a benign course and a reconstitution of the affected bones to a practically normal, though somewhat deformed and undersized state.

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AN OPERATION FOR RECURRENT DISLOCATION OF THE SHOULDER

BY PERCY W. ROBERTS, M.D., NEW YORK, N. Y.

The fact that numerous operations have been proposed for surgical control of recurrent dislocation of the shoulder joint is evidence that all of them are lacking in some essential feature. It seems proper, therefore, to record a procedure which I have used twice during the past year which for simplicity and excellent functional results leaves little to be desired.

Before describing the operation, I wish to call attention to an observation made while undertaking studies on the cadaver which led to my adoption of the tendon-suspension principle of retaining the humeral head in its normal relation to the glenoid fossa. It is obvious that deflection of the tendon of the long head of the biceps across the head of the humerus to the upper margin of the glenoid was designed to assist in retaining the head of the humerus in contact with the scapula. To determine the importance of this arrangement, all of the structures spanning the shoulder joint were severed except the tendon of the long head of the biceps. It was found that if the tendon was then held firmly against the shaft of the humerus it was impossible to dislocate the humeral head until sufficient force was exerted to rupture the transverse ligament passing from the greater to the lesser tuberosity which holds the tendon in the bicipital groove. It was evident, therefore, that, in a normal individual, tension of the tendon produced by contraction of the long head of the biceps is one of the important factors in maintaining stability of the shoulder joint.

Nicola having demonstrated that conversion of the upper part of this tendon into a ligament does not perceptibly restrict motion of the shoulder, I proceeded in the following manner to insure stability of joints which had been habitually dislocating over a period of years:

Through an incision over the anterior aspect of the shoulder following approximately the direction of the fibers of the deltoid muscle, the capsule of the joint was exposed and opened by a T-shaped incision to reveal the long tendon of the biceps. The course of this structure was outlined on the underlying articular cartilage with a knife. The transverse ligament was divided and the tendon was lifted from its natural bed and retracted. With a gouge the bicipital groove was extended upward and inward across the humeral head, following the markings previously cut in the cartilage. This channel was made sufficiently deep to permit the tendon, when replaced in it, to sink below the level of the articular cartilage. The transverse ligament was sutured and a stitch carried through both tendon and ligament. The capsule was closed, the split deltoid allowed to fall into place, and the skin sutured. The arm was then put up in a Velpeau bandage until the wound was healed, when the arm was placed in a sling and restricted use was permitted.

CASE 1. Male, aged fifty-two years. Admitted to the Hospital for the Ruptured and Crippled on December 9, 1931, with a subcoracoid dislocation of the right shoulder which had existed for several months. Patient gave a history of recurrent dislocation of the joint at frequent intervals, following an accident three years previous to admission. X-ray showed diffuse osseous changes in the humeral head, the greater tuberosity, and the acromion process. On opening the joint, the head of the humerus was found tightly bound down under the coracoid process, making reduction extremely difficult. The capsule was so firmly adherent to the head of the humerus that it was necessary to resort to sharp dissection to release it. The transverse ligament was ruptured, and the tendon of the long head of the biceps was so frayed at the level of the tuberosities that its continuity was preserved by a few fibrous shreds. With a gouge the bicipital groove was extended upward and inward, the tendon was repaired and placed in the channel cut for it, and a suture was passed through the tendon and the remnants of the transverse ligament. To permit union of the tendon, the arm was kept in a splint for several weeks before active motion was permitted. Return of function was slow in this case, as was to be expected in a joint so badly damaged, but eventually full range of motion was restored and there has been no recurrence of the dislocation.

CASE 2. Male, aged twenty-three years, athletic type. Admitted to the Hospital for the Ruptured and Crippled on June 2, 1932. He had sustained a dislocation of the right shoulder five years previously. Since that time the dislocation of the shoulder occurred at frequent intervals, often without unusual strain. He was operated upon the day after admission by the method described above. On the eleventh day a sling was substituted for the Velpeau dressing and moderate use of the arm was permitted. In four weeks joint motion was possible throughout the normal range. From the fifth week on the patient indulged in increasingly strenuous gymnasium work, including boxing, wrestling, and overhead lifting of heavy weights. He also performed exercises on the parallel bars culminating in "hand stands" with the trunk and legs extended vertically upward supported by the arms. In addition to this, he has played tennis and professional football. He has experienced no sense of handicap in athletics, nor has he been conscious of the slightest instability of the joint, notwithstanding the severe use to which it has been subjected.

While the results of two cases operated upon within a year do not establish beyond question the value of this method of stabilizing shoulder joints subject to recurrent dislocation, there is reason to believe that it will prove an effective means of controlling these troublesome disabilities.

A CASE OF COMPLETE DISLOCATION BETWEEN THE FIFTH AND SIXTH CERVICAL VERTEBRAE, WITHOUT FRACTURE

BY EDWARD N. REED, M.D., SANTA MONICA, CALIFORNIA

Complete dislocations between vertebrae, without fracture, are infrequent. In the cervical region they are usually fatal. The following case is of interest because of the complete dislocation without fracture, and because, in spite of severe cord damage, the patient not only survived but recovered a considerable amount of cord function.

Mrs. G. T., female, married, aged twenty-three years, on June 25, 1931, while playing on the beach, was lifted up and came down on the top of her head, with her neck flexed sharply forward. She was almost immediately paralyzed in all extremities. The paralysis was at first spastic but in a few hours it became flaccid.

Roentgenograms of her cervical spine showed an almost complete dislocation of the fifth cervical vertebra forward on the sixth. There was no evidence of fracture.

The neurological examination by Dr. Carl Rand showed a conscious and rational woman, suffering with considerable pain in the neck. Both lower extremities were completely paralyzed, with inability to move any muscle group. She was completely paralyzed in both forearms and hands. She was able to raise the arms at the shoulders, but could not lower them. She could flex both forearms but could not extend them. There was a complete loss of all forms of sensation ending abruptly at a level corresponding with the fifth and sixth cervical cord segments. The abdominal and epigastric reflexes were gone. The right biceps jerk was active, the left gone. Triceps, radial, and finger jerks were gone on each side. The knee jerks were quite active, the left being quicker than the right. The Achilles tendon jerks were active and equal. There was no Babinski on either side.

FIG. 1
Before reduction

FIG. 2
After reduction

Breathing was purely diaphragmatic. There was retention of urine.

On the following day all deep reflexes had disappeared.

Dr. John C. Wilson of Los Angeles reduced the dislocation on the day following the accident, by traction and manipulation, with the patient under anaesthesia. A head harness was put on, with two pounds of traction weight. Roentgenograms taken immediately after the manipulation showed a perfect reduction of the dislocation.

After six days the head traction was removed. The following day, on turning her head slightly, the patient felt something snap and immediately there was a return of severe pain in the neck. Roentgenographic examination showed a recurrence of the dislocation between the fifth and sixth cervical vertebrae. Dr. Wilson was away from the city at this time and the author was called upon to reduce the dislocation, which was again accomplished by traction and manipulation, and the reduction checked by x-ray. The head traction, with two pounds of weight, was kept on for four weeks, and on its removal a Thomas Collar was applied, which was worn for two months.

In spite of scrupulous care the patient developed an extensive ulcer over the sacrum. This was healed at the end of six months.

At the end of two months there were still increased reflexes in all four extremities, with ankle clonus and Babinski reflexes on both sides. But there was considerable motor return in the upper extremities and beginning of motion in the legs, with good tactile sensation and some pain and temperature sensation in all four extremities.

The patient ran a temperature throughout the first five weeks, over 105 degrees, axillary, on two occasions; at the beginning of the sixth week the temperature again became normal.

Control of bladder and rectum were lost and at time of last check-up, on April 4, 1932, had not been regained.

Examination on April 4, 1932, showed: Babinski reflex present on both sides, no ankle clonus, knee jerks exaggerated, from the suprapubic region downward tactile sensation but no pain or temperature sensation.

There is marked incoordination and muscular overaction in the lower extremities. Coordination in the upper extremities is fairly good. She can write a little. Sensation is good. She is beginning to walk in braces and with the aid of low parallel bars.

DISLOCATION OF A SINGLE CUNEIFORM BONE

BY DWIGHT F. CLARK, M.D., AND H. A. QUINT, M.D., EVANSTON, ILLINOIS

From the Surgical Department of the Evanston Hospital

It is apparently necessary that an unusual dislocation, such as that of a single cuneiform bone of the foot, be produced by an unusual mechanical force. A review of the literature shows scarcely a half dozen references in which mention is made of a dislocation of the anterior tarsal bones of the foot. None refer to the displacement of a single cuneiform bone.

The following case is reported at this time inasmuch as more than a year has passed since the injury and it is possible to comment satisfactorily on the end results:

On October 26, 1931, Mrs. M. S., aged twenty-seven, was driving an automobile which, by the time it had skidded off the pavement, had succeeded in reducing its speed to a moderate rate when it collided with a tree. The patient stated that her right foot became doubled under the brake pedal at the time of impact; that she felt no particular pain at the time of injury; and that only a sense of numbness was experienced when she was removed to another automobile and taken home. Examination of the foot at that time showed no laceration of the skin but a considerable swelling of the dorsum of the right foot and inability to bear the weight on it. While roentgenograms at that time showed no injury to the right leg bones, there was found a dislocation of the middle cuneiform bone and also a fracture of the distal extremity of the third metatarsal bone of the right foot. Under nitrous oxid gas at the Evanston Hospital the same day, an effort was made to reduce the cuneiform dislocation and a plaster cast was applied with the foot in extension, on account of the apparent tendency to redislocation if the foot was allowed to return to dorsiflexion. Films taken the following day showed that reduction had not been satisfactorily accomplished. Two weeks later, after immobilization in different positions with such pressure applied as was borne well, only a slight improvement was noticed in the position of the cuneiform bone. It was therefore concluded that reduction and maintenance of this bone could not be accomplished in our hands and an open operation was decided upon for correction of the deformity. Dr. John L. Porter, who examined the patient, was in agreement with this decision. On November 16, 1931, or approximately seven weeks after the original injury, a curved longitudinal incision, two and one-half inches in length and centered over the cuneiform deformity, was made, having enough lateral convexity to escape the promontory of the dislocation. The exposure of the middle cuneiform bone, after retraction of soft parts down to the periosteum, showed that the bone was not capable of being replaced in its former position without completely freeing it from its surrounding attachments and performing what would appear to have been a mutilating procedure with risk of jeopardizing future function. The alternative of an osteotomy confined to the middle cuneiform bone was therefore performed. A gouge chisel was driven across the elevated portion so that that part of the bone was not only removed flush with the dorsal curve of the tarsus but enough was removed so that a slight concavity remained. The fascia and soft parts were stitched over with considerable care so that a smooth surface for the superimposed tendons might exist. The accompanying illustrations show the original dislocation of the cuneiform bone, the fracture of the distal extremity of the third metatarsal, the failure of various attempts at reduction and maintenance, and the final satisfactory result of the osteotomy together with the development of callus in the fractured metatarsal. The patient has been able to dance and use the foot without pain. Examination at this date shows no apparent difference in

FIG. 1
Roentgenograms taken immediately after injury October 26, 1931.

FIG. 2
Roentgenograms taken ten days later, after unsuccessful attempts at reduction.

FIG. 3
Roentgenograms taken five weeks following injury, after osteotomy of cuneiform bone.

the appearance or contour of the two feet, although the patient still experiences some slight pain in bad weather or after overuse. It is now possible for her to be fitted with mated shoes. It has come to be our conclusion that what disability existed may now be attributed more to the irritation at the site of the fracture at the distal extremity of the third metatarsal bone than to the cuneiform dislocation and subsequent osteotomy.

This case is brought to your attention partly on account of its rarity and partly because of the probability that such cases occur more often than may be supposed. It is fair to assume that an appreciable number of foot injuries, diagnosed as sprains, may really include a tarsal cuneiform dislocation. It is also probable that improperly taken x-rays, especially those taken in the lateral position with a certain degree of rotation, may fail to bring out such an anomaly even when well interpreted. Furthermore, there may be no doubt but that inexperience in interpretation in either good or bad films is responsible for the neglect of recognition and proper treatment of this important and disabling injury. It is our conviction that, like carpal dislocations, the laying down of fibrous tissue in the bed of the misplaced bone soon makes reduction mechanically impossible and it may not be successfully accomplished even when attempted very early. Inasmuch as the very few instances of record show both in treated and untreated cases rather uniformly poor functional and anatomical results, it stands to reason that if we would preserve the spring in the patient's step, avoid permanent injury to the arch, and prevent a permanently thick and painful foot that can be fitted to shoes only with difficulty, this supposedly unusual injury should be added to those we must consider in the differential diagnosis of injuries to the forefoot.

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CARPOMETACARPAL ARTHROPLASTY OF THE THUMB

BY ROBERT PATTERSON, M.D., KNOXVILLE, TENNESSEE

Ankylosis of the thumb with the digit lying in the same plane as the hand renders the member practically useless. This is especially true if the fingers are stiff in complete extension, and the hand is swollen and indurated from passive congestion and disuse.

The problem presented in these cases is four-fold:

1. To overcome the flat hand deformity;
2. To flex the fingers and restore motion, especially apposition to the thumb;
3. To overcome brawny swelling and promote normal circulation;
4. To mobilize the thumb and develop its power of apposition to the fingers.

The first three indications are met by procedures well known to orthopaedic surgeons, but in dealing with an ankylosed thumb I was astonished to find only one reference to an arthroplasty of the carpometacarpal joint. MacAusland[1] states that this case was successful, and that the patient used the thumb in ten days.

CASE REPORT

While driving an automobile in December 1931, Mr. V. L. was "side-swiped" by another car, while his left arm was projecting from the window. He received a compound comminuted fracture of the left elbow, and a Bennett's fracture of the left thumb.

Upon examination April 1, 1932, I found he had a painless range of motion in the elbow, from 90 degrees to 135 degrees, with some rotation. The thumb was ankylosed at forty-five degrees' abduction. The axis of the thumb coincided with that of the hand.

There was a slight "give" at the carpometacarpal joint, the ankylosis being fibrous. The hand was greatly increased in size, flat and indurated, with the fingers stiff in complete extension. The roentgenogram showed about one-third of the inner portion of the base detached, and lying between the first and second metacarpals, preventing adduction. It was decided to restore the use of the hand, as the first step in the restoration of the function of the arm.

TECHNIQUE OF OPERATION

On March 30 an operation was performed as follows:

A straight incision was made, extending from the dorsal surface of the interphalangeal joint of the thumb proximally, and passing over the "anatomical snuff box" between the extensor tendons. The incision was carried to the bone between these tendons which were retracted to different sides. The carpometacarpal joint was opened. Dense adhesions were encountered as the joint surfaces were exposed, by completely severing these and the capsule beneath. The displaced portion of the head was removed with considerable difficulty. In doing so the radial artery was torn. The profuse hemorrhage that ensued was controlled by a tourniquet, and the operation was completed. It was found later that simple pressure with dressings and elevation controlled the bleeding.

The base of the metacarpal was freed entirely from the surrounding soft tissues and

FIG. 1

FIG. 2

Showing range of voluntary motion in thumb and fingers, July 18, 1932.

brought out of the wound. The cartilage was practically gone. Sufficient of the bone was removed to permit free motion, and the surface was rendered smooth with a file. No attempt was made to reproduce the exact shape of the normal joint surface; it was simply rounded off. A strip of fascia lata of sufficient size was removed and wrapped around the head, and held in place with purse-string suture. The inner glistening surface of the fascia was placed externally or next to the joint. The greater multangular joint surface showed evidence of disuse, but was little damaged. The wound was closed and a cast was applied with the thumb abducted and drawn medialward over the palm.

Active motion was begun the twelfth day. Measures were instituted to restore form and function to the rest of the hand at the same time and continued daily. There was surprisingly little pain and soreness in the new joint after two weeks.

Efforts to flex the fingers were continued until the end of May, but were fruitless on account of the contracture of the thickened capsules. Open posterior capsulotomies were accordingly performed May 30, 1932, by the subperiosteal elevation method of Silver. Flexion was then easily secured and maintained to a large extent. Physiotherapy was continued for several weeks.

RESULTS

The range of motion of the thumb is normal and power to grasp all but very small objects has been restored, as is shown by the illustrations. Patient was able to return to work as a truck driver, September 1932.

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OLD DISLOCATION OF THE SHOULDER

A New Instrument for Reduction * †

BY WILLIAM ARTHUR CLARK, A.M., M.D., F.A.C.S., PASADENA, CALIFORNIA

On attempting to reduce an old dislocation of the shoulder by traction there is no stable point for countertraction. The heavy pectorals and the other muscles inserted near the head of the humerus transmit the pull to the whole shoulder girdle, which is thereby displaced in the same direction as the humerus when traction is made on the arm. Even in attempting open reduction, a fulcrum for leverage is not available. In attempting these open reductions it is seen that some method for getting countertraction directly on the scapula is needed.

The simple instrument described below will exert adequate traction on the head of the humerus and at the same time hold back the glenoid.

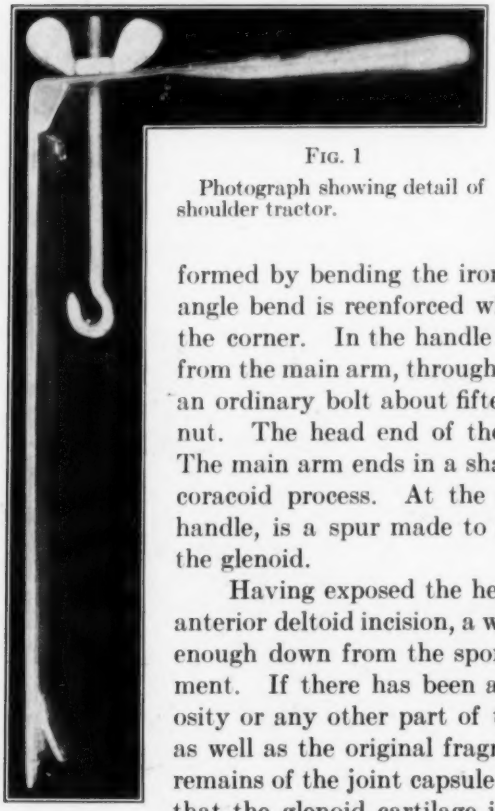

Fig. 1

Photograph showing detail of shoulder tractor.

The instrument is made of heavy strap iron two and two-tenths centimeters wide. The main arm is thirty centimeters long and a handle sixteen centimeters long is formed by bending the iron at a right angle. The right-angle bend is reenforced with a wedge of iron soldered in the corner. In the handle part is a hole two centimeters from the main arm, through which is passed, fitting loosely, an ordinary bolt about fifteen centimeters long, with wing nut. The head end of the bolt is reshaped into a hook. The main arm ends in a shallow fork made to straddle the coracoid process. At the end, on the same side as the handle, is a spur made to impinge against the margin of the glenoid.

Having exposed the head of the humerus through an anterior deltoid incision, a wire is passed through it, just far enough down from the spongy bone to get a firm attachment. If there has been a fracture of the greater tuberosity or any other part of the head, the resulting callus, as well as the original fragment, must be removed. The remains of the joint capsule is opened up and retracted so that the glenoid cartilage is visible. Muscles and fascia must be cut from the distal third of the clavicle and

* From the Orthopaedic Department, Los Angeles County Hospital. Service of Dr. T. M. Hart.

† Presented at the Annual Meeting of the American Orthopaedic Association, Toronto, June 18, 1932.

FIG. 2

Tractor applied with end on the coracoid.

reflected forward to get a good exposure of the coracoid process as well as of the dislocated head. It has been found necessary to sacrifice practically all of the muscle attachments around the head so that it is completely free to be pulled out.

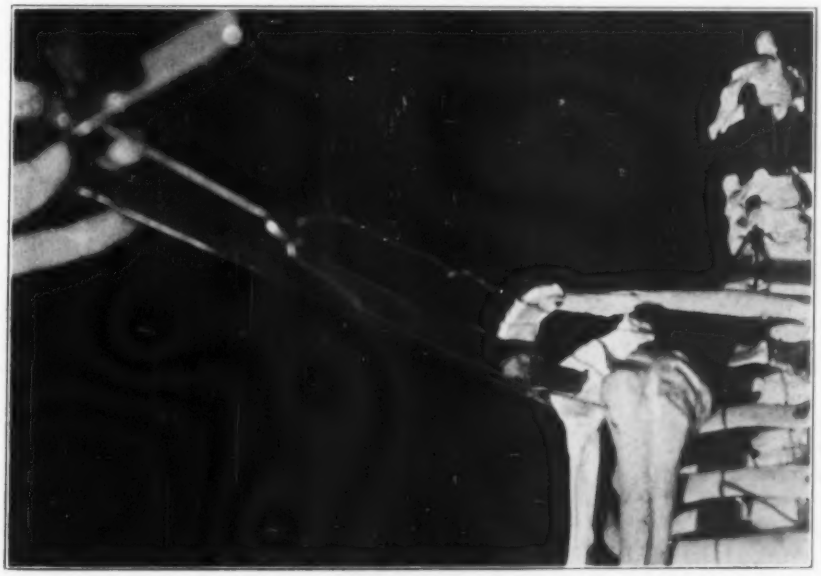

FIG. 3

Tractor applied with end on edge of glenoid.

FIG. 4

Subcoracoid dislocation with fracture and separation of greater tuberosity. (Callus mass outlined by mark.)

FIG. 5

Same case as in Fig. 3, after removal of callus and reduction.

The forked end of the extension tractor is then set firmly against the base of the coracoid process and the wire placed over the hook. Gradual traction is then obtained by means of the winged nut. When the head is well out from under the coracoid and at the level of the glenoid fossa, the traction is released and the tractor changed from the coracoid to the posterior margin of the glenoid, the spur at the end of the tractor being made to impinge against this margin. Traction is again applied. By manoeuvring the tractor, the proper direction of pull can be obtained to bring the head of the humerus into the glenoid fossa. The long head of the biceps tendon should be kept anterior to the head of the humerus.

I have used this tractor successfully on four cases. The first was a woman with a subcoracoid dislocation and fracture of the greater tuberosity which had remained unreduced for seven weeks. Attempt at closed reduction under gas failed, even after the arm had been in continuous skeletal traction for ten days. The result of open reduction with the aid of the tractor is shown in Figure 2. Three months later the head was still in normal position and function good.

The second case was of a very muscular man of fifty-seven with a subcoracoid dislocation of two months' standing. This was a very difficult case, but the head was finally manoeuvred into the glenoid fossa. Two months later the patient reported that the shoulder was still in place and, although motion was not normal, he was using the arm and noticed gradual improvement.

Case 3 was that of a Mexican sixty-two years of age. A subcoracoid dislocation had persisted for three months. It was reduced April 1, 1932. The long head of the biceps was accidentally ruptured near the glenoid and had to be sutured after the reduction. Motion was started in two weeks. Later information could not be obtained at this writing.

Case 4 (with Dr. Hart) was the most difficult of all, although the subcoracoid dislocation had been present only five weeks. The patient was a man of about fifty-five. The difficulty was due to our attempt to reduce it without sacrificing the muscle attachments around the head. It was thought that this might be done in view of the comparatively short duration of the lesion. However, after breaking the tip of the coracoid by counterpressure, the muscles had to be sectioned at the head. Counterpressure was then transferred to the posterior margin of the glenoid and reduction accomplished.

The instrument has been used successfully by three other surgeons in one case each, one being a dislocation of six months' duration.

IMPROVED APPARATUS FOR RUSSELL TRACTION

BY D. O. CHAMBERLAIN, M.D., BROOKLYN, NEW YORK

Kings County Hospital

In 1924, R. Hamilton Russell of Melbourne, Australia, described a system of treatment of fracture of the femur which has been employed frequently at Kings County Hospital. The setting up of the necessary apparatus entails considerable work, a fact appreciated by the writer who was confronted with five such requirements in his first six days on the Fracture Service, so that a short cut was precipitated.

The apparatus, as shown in Figure 2, consists of a three-quarter inch, curved, galvanized iron pipe, thirty inches long with straight ends which permit telescoping of twelve inches, the intermediary six inches being curved to make an angle of 150 degrees. A bed hook which was designed by L. W. Roessler, a bracemaker of the Mayo Clinic, and described by Hugh T. Jones, is attached on the concave surface twelve inches from the lower end. Both ends have a collar through which a set-screw is sunk and from which protrude snugly fitting iron bars twelve inches long, bearing one pulley for the upper end and two for the lower.

The apparatus was constructed primarily for beds with a high horizontal bar, though with slight modification it could easily be made to fit any bed. Turned concave side upward, the lower pole is introduced from the foot of the bed through the space between the vertical bars which will be closest to the injured member, until the arms of the hook come in contact with the neighboring vertical bars of the bed. The apparatus is then rotated about the cross bar as its axis describing an arc

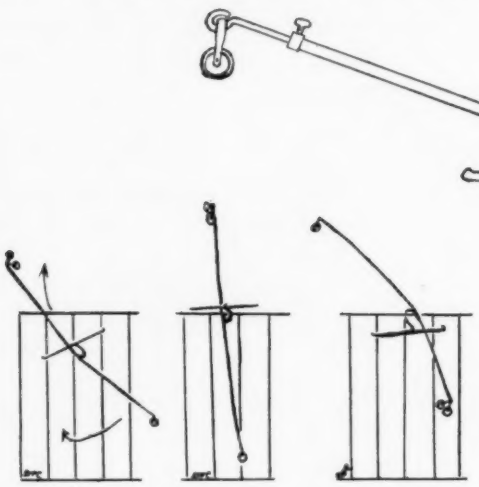

FIG. 1

Stages in application of apparatus to foot of bed.

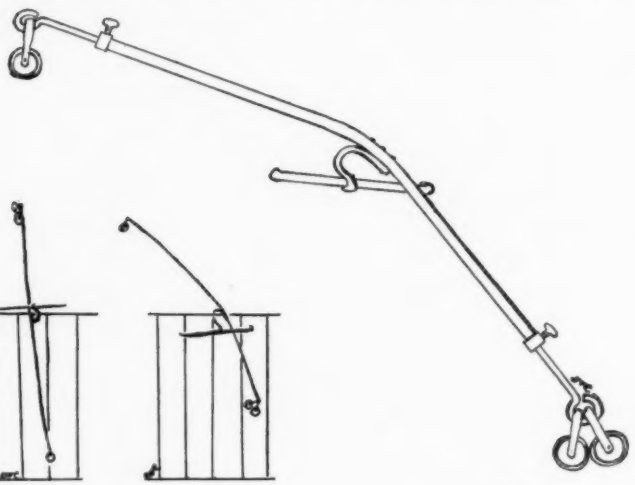

FIG. 2

The apparatus.

FIG. 3

The apparatus in use.

of 180 degrees (end for end). The concavity is now downward, the long pole directed upward over the leg, the short pole downward toward the floor.

The telescoping pulleys are then adjusted in the position described by Russell. The six-inch inequality in length of poles is balanced when weights are applied for the traction.

Aside from the ease of application, interference with the x-ray tube is avoided and there are no parts to get lost.

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MODIFICATION AND EXTENDED USES OF BRADFORD FRAME

BY GEORGE M. LOGAN, M.D., AKRON, OHIO

Since the Bradford frame, or some modification of it, is so frequently used in maintaining patients, suffering from various conditions, in the recumbent position, its use could be extended greatly and certain other types of patients be handled with greater ease, safety, and comfort, if it were but made more comfortable to the patient.

The original Bradford frame, even with a supporting strip beneath buttocks, is not comfortable to patients because of parts sinking through the wide, rectangular-shaped aperture when the supporting strip is in position and particularly so when it is removed to permit use of the bedpan. In the latter case it often permits more movement of the parts than is desirable from the standpoint of attempting to maintain immobilization, and also permits a resultant position certainly not desirable from the standpoint of comfort of the patient.

These objections to the original Bradford frame can be overcome largely by modification in the construction of the canvas support; and with a moderate amount of care in placing the patient on the canvas, the modified Bradford frame serves all the purposes of the original. The essential modifications are the changing of the rectangular-shaped aperture in the original to a diamond-shaped one in the modification and supporting the margins of the diamond-shaped aperture by strips of the same material along margins of the aperture, extending to the outer margins of the canvas, for reenforcement and to prevent sagging at the point where the maximum weight is sustained.

The essential features of construction and uses of this modification are:

1. Heavy, firm material—twelve-ounce white duck.

2. Supporting strips, of same material eight inches in width, securely sewed to the under side of the main canvas in diagonal direction, one margin of which reenforces the diamond-shaped aperture through the main body of the canvas. Margins of aperture of main top duck to be bound over margin of supporting strips.

3. Care should be exercised in construction of main canvas not to cut too much material in forming aperture that the margin may be securely bound and finished.

4. A three-inch hem around four outer margins of main body of canvas securely sewed.

5. Metal grommets inserted securely along center of hem at intervals of three inches.

6. Aperture slightly closer to one end of main canvas than the other—canvas shown in Figure 1—designed as thirty-three inches is to

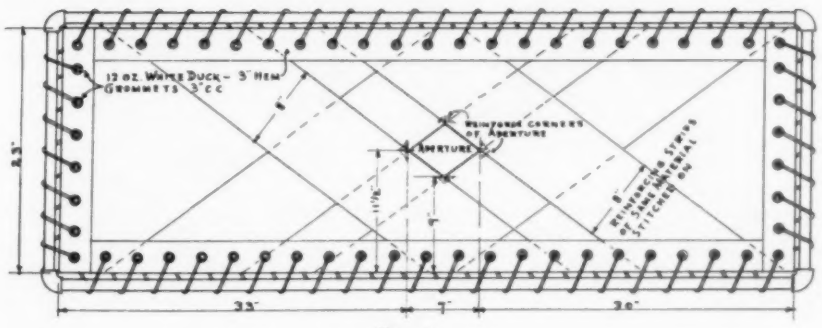

FIG. 1

Modification of the Bradford frame by the author.

thirty inches to provide for patients of different proportions. For patient having long legs and short body the short end should be toward the head, etc.

7. The sewing at angles of aperture should be reenforced by heavy linen thread.

8. The modified Bradford frame should be attached to a frame of gas-pipe of proper size,—two inches wider and two inches longer than measurement of main canvas and made of one-quarter inch to five-eighths inch gas-pipe, the same as the original Bradford frame. The smaller sizes are used for children.

9. The modified Bradford frame may be attached to bed by doubly curved straps of iron as in original Bradford frame.

10. Canvas tightly laced to gas-pipe as in original Bradford frame by window-sash rope or bell cord.

11. Top of Bradford frame when in use should be dressed separately in halves by at least four thicknesses of blanket and two thicknesses of sheet under body and leg portions and by combination abdominal pads made of cotton folded in gauze under buttocks at sides of aperture.

12. In case the Bradford frame is used for a patient with incontinence of urine, a rubber sheet thirty inches by twenty-three inches may be used with an opening in the center made by cutting, as in a crucial incision, slightly less in extent than the width or length of the aperture, so that the points of the rubber dam thus formed will hang down through the aperture and conduct the escaping urine into a bedpan beneath the frame without soiling the canvas.

13. The modified Bradford frame may be used to advantage in all cases endangered by unnecessary moving and lifting on bedpans,—such as injured and fractured spines and pelves and thighs, with or without plaster-of-Paris casts or other supporting apparatus; and in cases with incontinence of excreta and in all other subjects too dangerous, painful, or burdensome to be lifted upon a bedpan.

14. Dimensions of modified Bradford frame may be varied easily, either wider or narrower or longer, to suit patients of extraordinary sizes.

15. The Whitman modification of the Bradford frame, in which the longitudinal arms of the rectangular gas-pipe frame are curved, thus permitting the hyperextension of the spine in any desired segment as may be indicated, may be added.

16. A Balkan frame may be erected over the modified Bradford frame as over the original.

17. Where traction in longitudinal direction is required, the patient is easily maintained in the proper position on the frame by elevating the foot of the bed sufficiently to enable gravitation of patient to balance traction toward head of bed.

NATHANIEL ALLISON

NATHANIEL ALLISON

May 22, 1876–August 30, 1932

The medical profession of America has lost a noted surgeon; the American Orthopaedic Association an eminent member, wise in its counsels, a friend of many and the companion of a few.

Nathaniel Allison, born in Webster, Missouri, May 22, 1876, was the son of James Allison, pioneer merchant, and grandson of Dr. Nathaniel Allison, pioneer physician of Audrain County, Missouri. The family tree sprang from early English, Colonial, and Revolutionary soil. Schoolboy days were spent in St. Louis at Smith Academy, and at seventeen he was admitted to West Point. At the end of a year the medical life of his greatly beloved grandfather made a stronger appeal than the military career which West Point offered. Further preparation at the Penn Charter School in Philadelphia enabled him to enter Harvard College in 1894. He transferred to the Medical School in 1897, and received his M.D. in 1901. After a training in Orthopaedic Surgery at the Boston Children's Hospital, he settled in St. Louis and was extraordinarily successful in combining laboratory research with clinical work, gaining the respect which his ability and industry deserved.

In 1909, he married Marion Aldrich of Chicago.

Few Americans had a more interesting or useful war service than Dr. Allison. He was commissioned as Captain and discharged as a full Colonel. Even before the United States entered the War, he had served with the American Ambulance in Paris. Later he was a member of the Army Board which standardized the splints and dressings of the American Expeditionary Forces. On his shoulders rested the chief responsibility for an adequate supply of these necessities. The problems of French manufacture, of American transportation, and of proper training of officers and stretcher-bearers in the application of these splints were knotty problems which he untangled with great skill and patience. On his return to America in 1919, he was assigned to the Walter Reed Hospital as Assistant Director of the Surgical Service and, in September 1919, after his discharge, was sent to Rome as representative of the Medical Department of the Army at the Inter-allied Congress of Surgery. The President of The United States awarded him the Distinguished Service Medal.

On his return to St. Louis, Dr. Allison was made Dean of the Medical Department of Washington University, continuing with his other duties as head of the orthopaedic teaching and hospital staff of the Medical School. In 1923, his medical Alma Mater called him to Boston and he became Professor of Orthopaedic Surgery in the Harvard Medical School and Chief of the Orthopaedic Department of the Massachusetts General Hospital. In 1929, he was invited by the University of Chicago to become a Professor of Surgery in charge of the Division of Orthopaedic Surgery and this invitation he accepted. These heavy responsibilities he continued to discharge until illness made it necessary for him to lay them down in 1932.

Dr. Allison's orthopaedic bibliography is voluminous. His monographs deal with almost every phase of the specialty in war and in peace. Clinical leads were followed into laboratory research, chiefly in association with Dr. Barney Brooks, then his St. Louis colleague. Their significant articles on "The Mobilization of Ankylosed Joints", on "Arthroplasty: Experimental and Clinical Methods", and on "Bone Atrophy: an Experimental Study of the Changes in Bone which Result from Non-Use" were published in 1915, 1918, and 1921, and represent important contributions to the knowledge of essential bone reactions. In addition to his contributions to current medical literature, he edited the orthopaedic sections of several Systems of Surgery. In 1929, with Dr. Frank R. Ober as American coeditor, and Sir Robert Jones and Mr. Harry Platt, F.R.C.S., as British coeditors, he prepared the revised second edition of Jones and Lovett's "Textbook of Orthopedic Surgery". In 1931, in collaboration with Dr. Ralph K. Ghormley, he published "Diagnosis in Joint Disease: A Clinical and Pathological Study of Arthritis"; and in 1932, in collaboration with Dr. Robert B. Osgood, "The Fundamentals of Orthopaedic Surgery in General Medicine and Surgery".

If "a man is known by the company he keeps", Dr. Allison was well known as a partial list of the medical and civic societies to which he belonged abundantly attests: fellow of the American College of Surgeons, of the New England Surgical Society, and of the American Academy of Arts and Sciences; honorary member of the British Orthopaedic Association; corresponding member of the Société des Chirurgiens de Paris; member of the American Orthopaedic Association (President, 1922), the International Society of Orthopaedic Surgery, the American Medical Association, Southern Surgical Association, Association of Military Surgeons, Massachusetts Association for Occupational Therapy (President, 1925–1929), the St. Louis Surgical Society, Boston Orthopaedic Club, and many urban and country clubs in St. Louis, Boston, Chicago, and Washington.

Wherever this genial but self-contained and unhurried physician practised, he became a vital element in the professional life of the community and the trusted adviser of important medical institutions. He was independent in thought and action and by the exercise of his own wisdom and effort usually attained the end sought. He broadened the scope of Orthopaedic Surgery by research; and increased its prestige by the respect in which he was held by medical and surgical colleagues, a respect engendered by his knowledge of men and of medicine.

RUSSELL A. HIBBS

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Dr. Russell A. Hibbs, Surgeon-in-Chief of the New York Orthopaedic Dispensary and Hospital and Professor of Orthopaedic Surgery in the College of Physicians and Surgeons, Columbia University, died in New York on September 16, 1932. His death is an incalculable loss to Orthopaedic Surgery. Early in his career he began the long list of notable contributions which continued to the end.

In 1902 he wrote a prize essay on the treatment of fractures of the femur. In the same year he pointed out the harmful results which often followed subcutaneous tenotomy of the tendo achillis, and in 1906 published a new method of lengthening the Achilles and other tendons. "An Original Method of Operating on Congenital Dislocation of the Hip" appeared in 1908.

"An Operation for Stiffening the Knee Joint" was published in 1911. Perhaps his greatest achievement, the spine fusion operation, was described in a paper called "An

Operation for Progressive Spinal Deformities," appearing in the same year. Although this was first used in the treatment of Pott's disease, the title shows that Dr. Hibbs foresaw the possibilities of the procedure in other conditions, a vision which soon was fulfilled in its application to scoliosis, fractures, abnormalities of the lumbosacral region, etc. It is not exaggerating to say that the operation has revolutionized the treatment of those conditions.

A paper on "Muscle-Bound Feet", including the application of the new method of lengthening the tendo achillis to this condition, was printed in 1914 and was followed by one on "An Operation for Claw-Foot" in 1917. The first résumé of the results of spine fusion in the treatment of lateral curvature was given in 1923 in "A Report of Fifty-Nine Cases of Scoliosis Treated by the Fusion Operation." The last great triumph came in the perfecting of a method for fusing the hip. This was published in 1926. Any one of these papers would have secured for him a lasting place in the roll of those who have done great things for Surgery. That this whole list should have come from the hand of one man is truly remarkable.

Dr. Hibbs's name probably will be identified most conspicuously with treatment of joint tuberculosis. He was at first almost alone in believing that it could be cured only by fusing the joint, and his steadfast adherence to this principle in the face of widespread opposition, together with his skill in developing methods for carrying it into effect, have made him, more than any other, responsible for its general acceptance today. Surely it is not too much to say that he was among the very foremost in placing Orthopaedic Surgery on a modern footing and making it a real part of Surgery.

Only his associates know the many other sides of this remarkable character. He was a genius in organization and administration. When he was appointed Surgeon-in-Chief of the New York Orthopaedic Dispensary and Hospital at the age of thirty, it was a small institution occupying a converted dwelling house. His great ability and enthusiasm won the support which made possible the development of the hospital to its present greatness. In 1903 he founded the New Jersey Orthopaedic Hospital and was afterward responsible for its conduct on the same lines as his own hospital.

His interest in medical education and his insistence upon the need for better postgraduate training for surgeons led to the establishment of the Annie C. Kane Fellowships at the Orthopaedic Hospital. His lectures at the College of Physicians and Surgeons aroused the keen interest of all the students and made his course one of the most popular in the curriculum. His personality left its stamp on every young man who went through his hospital as a house officer. He loved nothing better than to meet and talk with the alumni and his interest and warm sympathy were a source of lasting inspiration to them all.

Dr. Hibbs was born at Birdsville, Kentucky, on September 1, 1869. He attended Vanderbilt University and was graduated from the Medical College of the University of Louisville in 1890. After practising for several years in Texas he went to New York and in 1894 became Resident Surgeon at the New York Orthopaedic Dispensary and Hospital. Six years later, in 1899, he was made Surgeon-in-Chief. He was appointed Professor of Orthopaedic Surgery at the College of Physicians and Surgeons, Columbia University, in 1918. He was president of Hope Farm, a community home for children, a member of the American Orthopaedic Association, the Interurban Orthopaedic Club, the Practitioners' Club, the Union Club, a fellow of the American Medical Association, the American College of Surgeons, and the New York Academy of Medicine. He was consulting surgeon of the Presbyterian, French, Babies', Sea View, and Beekman Street Hospitals, the New York Infirmary for Women and Children, and St. John's Riverside Hospital, Yonkers, New York.

On September 1, 1904, Dr. Hibbs married Miss Madeline Cutting, daughter of the late Walter Cutting, at Pittsfield, Massachusetts. She survives him, as well as a brother and two sisters.

News Notes

Dr. Edward S. Hatch announces that Dr. Dudley M. Stewart is now associated with him in practice. Their office is located at 3505 Prytania Street, New Orleans, Louisiana.

By invitation of the Board of Trustees of the Bishop Clarkson Memorial Hospital, friends of the Hospital gathered on Sunday afternoon, December 4, for the unveiling and presentation of a portrait of Dr. John Prentiss Lord. The portrait was a gift to the Hospital from the Staff in recognition of Dr. Lord's long and faithful service to the Institution.

The Annual Meeting of the Interurban Orthopedic Club was held in Buffalo on October 28 and 29. An unusually interesting program was offered by the Committee and by the orthopaedic staffs of the Buffalo hospitals. Cases were presented at the Buffalo General Hospital, The State Institute for the Study of Malignant Disease, and the Children's Hospital, and rather remarkable results of treatment of various cases were shown in these demonstrations.

At the Meeting of the **Chicago Orthopaedic Club** on November 11, Dr. Ferdinand Seidler presented a paper on "The Shelf Operation in Stabilization of the Hip", and Dr. Leo F. Miller spoke on "Orthopaedics as Seen in the Clinics of Prof. Riccardo Galeazzi and Prof. Vittorio Putti". General discussion followed the presentation of these papers.

The Journal has been informed of the recent death of Miss Jane A. Neil, formerly principal of the Spalding School for Crippled Children in Chicago. The Spalding School, of which Miss Neil became principal in 1914, was the first school of its kind in the country. In 1928, Miss Neil became district superintendent of special schools in Chicago and she instituted many new courses in the schools under her supervision. She maintained that "education of the crippled child is not philanthropy but enlightened self-interest".

At the Meeting of the **British Orthopaedic Association,** held in London, July 27, 1932, the following officers were elected to serve for the year 1933:

Emeritus President:	Sir Robert Jones, Bart., K.B.E.
President:	A. S. Blundell Bankart
Vice-President:	S. T. Irwin
Hon. Treasurer:	W. R. Bristow
Hon. Secretary:	E. P. Brockman
Editorial Secretary:	G. Perkins
Executive Committee:	P. Jenner Verrall
	S. A. S. Malkin
	S. L. Higgs
	W. A. Cochrane

At the **Réunion d'Orthopédie et de Chirurgie de l'Appareil Moteur de Bordeaux** on June 9, 1932, a large number of interesting papers were presented by the members and guests. The following list will demonstrate the wide scope of subjects considered and the interesting and important papers presented:

The Myeloplastic Tumor of the Upper Portion of the Fibula, with Partial Resection. By Dr. Charles Lasserre.

Subtrochanteric Osteotomy for Support in Pseudarthrosis of the Neck of the Femur. By Dr. André Treves.

The Problem of Hyperdactylia. By Dr. Max M. Klar.

Vertebral Epiphysitis in a Patient of Thirty-Eight Years. By Dr. René Gourdon.

Four Cases of Vertebral Epiphysitis in Adolescents. By Dr. Benoiste-Pilloire and Dr. René Gourdon.

Femoral Metaphysitis. By Dr. Benoiste-Pilloire and Dr. René Gourdon.

Multiple Congenital Malformations. By Dr. Benoiste-Pilloire and Dr. René Gourdon.

The Technique of Ankylosing the Upper Extremity of the Femur in Deforming Osteo-Arthritis of the Hip. By Dr. H. L. Rocher.

A Severe Fracture of the Calcaneum, with Immediate Reduction under Local Anaesthesia. By Dr. H. L. Rocher.

Bilateral Congenital Dislocation of the Radius. By Dr. Charles Lasserre and Dr. Saft.

Osteomyelitis of the Two Hips at Nine-Year Intervals. By Dr. Edouard Papin.

An Unusual Lesion of the Cervical Region. By Dr. Edouard Papin.

Complete Osteogenic Absence and Ankylosis at the End of Eight Months in Extra-Articular Arthrodesis Performed for an Old Congenital Dislocation of the Hip. By Dr. Charbonnel and Dr. Masse.

Old Luxation of the Elbow Treated by Osteotomy of the Olecranon. By Dr. Robert Guerin.

At the **14e Réunion Annuelle de la Société Française d'Orthopédie,** held in Paris on October 7, 1932, the special subjects considered were "The Surgical Treatment of Scoliosis" and "The Early Treatment of Acute Osteomyelitis".

Dr. Fèvre, of Paris, presented the subject of Surgical Treatment of Scoliosis. He took a moderate position in regard to the surgical treatment, reserving it for cases which have had prolonged conservative methods and those in which the conservative treatment is not particularly encouraging,—for instance, in paralytic scoliosis. He presented a new method of procedure, simple and rapid, which provides a large area for the graft.

The Early Treatment of Acute Osteomyelitis was presented by Dr. Ingelrans, of Lille. He gave a review of the different forms of treatment, including vaccination and the total and early excision of the diaphysis, as well as the simple periosteal incisions with or without trephining. In his conclusions he stated that, although early resection gives good immediate results if done under proper conditions, it is not always considered necessary, and up to the present there has been insufficient time to determine the complete end results.

At the **41e Congrès Français de Chirugie,** held in Paris in October, 1932, Prof. Cunéo, of Paris, and Prof. Rocher, of Bordeaux, discussed "The Surgical Treatment of Chronic Non-Tuberculous Arthritis of the Hip Joint".

A most complete presentation of this subject was given, too thorough and too complete for abstract. In the first part were discussed the essential features,—such as, etiology, pathology, clinical symptoms, and therapeutic indications. The second portion of the presentation was devoted to a consideration of the surgical technique of the various procedures.

The XXIII Congresso della Società Italiana di Ortopedia was held at the Istituto Rizzoli in Bologna on October 15, 16, and 17, under the leadership of the President, Prof. Riccardo Galeazzi, and a most interesting program was presented.

Professor Božidar Spišić, President of the Yugoslavian Orthopaedic Society, opened the **Congress of the Yugoslavian Orthopaedic Society and the Czechoslovakian Orthopaedic Society** at Zagreb on October 3 by his Presidential Address in which he considered especially the subject of the care of cripples and the position of orthopaedic surgery. Professor Spišić stated that, at the beginning of his work in Zagreb twenty-five years ago, orthopaedic surgery was unknown, but now its importance is being gradually recognized, as is seen by the organization of this new Society. He gave full credit to the men prominent in this specialty, both in Europe and in America, and acknowledged their influence in the development of orthopaedic surgery during the last two decades.

Along with this development there has also been the recognition of the need of the care of the cripple and his right to obtain such care. He stated that the cripple, although handicapped by his deformity, must still remain a part of the community and is, therefore, entitled to the opportunity for education and adequate training for self-support. He also called attention to the psychological effect of the cripple's physical infirmity and the need of reconstruction of his mental attitude, and pointed out that everyone in the community should contribute to this work. The cripple can and must be made a useful member of society, and to accomplish this it is necessary that some occupation be found for him of which he is capable. These goals were kept in mind in the founding of the Orthopaedic Hospital in Zagreb, and a large part of this Institution has been devoted to this special work.

The Society had a very successful meeting in which members from both Yugoslavia and Czechoslovakia took an active part.

Current Literature

THE DIAGNOSIS AND TREATMENT OF POSTURAL DEFECTS. By Winthrop M. Phelps, B.S., M.D., M.A., F.A.C.S., and Robert J. H. Kiphuth. Springfield, Illinois, Charles C. Thomas, 1932. $4.00.

In this rather unusual book the author has given the results of long study of this subject of posture, using an extensive series of examinations of young people of various ages, and has also considered the information which has been contributed by the several branches of medicine. Posture is presented as one of the considerations in the general problem of development and growth as influenced by environment and heredity.

In the first portion of the book the function of the structural variations are treated and many practical but often not sufficiently recognized conditions are demonstrated. The athlete is not necessarily perfect, and the normal posture must vary considerably with different ages. Various conditions connected with the development of posture and growth are clearly discussed and fully illustrated. Attention is called to the distinction which must be made between the pre-adolescent and the adolescent periods, and the author points out the influence of the instinctive play of children, as well as the more elaborate and organized exercises in the adolescent period, on the development of posture and posture defects. The percentage of physical defects in the pre-adolescent period is comparatively small and exercises are, therefore, at this time not so important.

Considerable stress is laid on and a chapter devoted to the subject of body mechanics, and the principal joint areas are analyzed with reference to their effect on the whole problem of posture. The defects of these areas are also given special consideration.

A large part of the work is devoted to the subject of posture examination and faulty posture, also to the effect of overdevelopment and overtraining which in general has not been given a place of sufficient importance in the treatises on this subject. In addition, the book contains rules for physical development and correction of posture faults and defects, as well as individual exercises, both developmental and corrective. A series of statistics of the classification and grouping of the different defects follows this portion.

By all students of posture, this book should be carefully studied.

A SHORTER ORTHOPAEDIC SURGERY. By R. Brooke, M.S., F.R.C.S. New York, William Wood and Company, 1932. $3.00.

The author states that this book was written with a view to meeting the needs of instructors in the medical schools and of the undergraduate students. The schools do not attempt to graduate students as specialists, but rather to provide them with a sufficient knowledge to serve as a foundation for their further experience and study, and this book is designed to aid in this education.

The author has chosen a very convenient and successful method of presentation,—considering each joint separately with the special affections to which it is subject, rather than describing the diseases with their special manifestations in the various joints. This method gives to the reader a very clear idea of the behavior of the joints under different conditions. There is sufficient anatomical description to serve as a basis for the later discussion of each subject, and the different diseases are discussed in their etiological, pathological, and diagnostic aspects. The various procedures of treatment—both conservative and operative—are considered, but not in too much detail; the reader is given, rather, a bird's-eye view of the subject, including the possibilities of the effect of the disease and the results of treatment. In the chapter on the foot the subject is treated a little more in detail, but the average young practitioner is very likely to be called upon to treat the conditions described and should be better fitted to do so. Par-

ticularly clearly are given in an excellent table the directions for the choice and the application of proper shoes for the various types of feet.

The book is fully illustrated by excellent photographs and drawings and will meet the need for which it is intended.

PRINCIPLES OF ORTHOPEDIC SURGERY FOR NURSES. By James Warren Sever, M.D., Ed. 2. New York, The Macmillan Company, 1932. $2.50.

As the title indicates, this work is primarily intended for the instruction of nurses. The avoidance of technical language, and the use of explanations when such language is used, makes the book of value for the student nurse. Careful attention given to the daily problems in orthopaedic nursing,—such as the nursing care of a child in a cast, the care of a patient with tuberculosis of the spine, bringing out the details of feeding and dressing problems, makes the work of special value to floor supervisors, graduate nurses, and others who have the care of orthopaedic patients.

Others than nurses will find the book helpful. Social service workers who must deal with the crippled will find their problems discussed. Medical stenographers, medical librarians, and the custodians of hospital record rooms may quickly gain knowledge of orthopaedic terms hereby, so that these terms mean more to them than peculiar collections of letters. Brace-makers will find described and illustrated the standard braces that are used over and over again in so many disabilities. The illustrations and descriptions should be helpful to those responsible for hospital paraphernalia.

Dr. Sever has developed this book through years of experience, and the fact that he has had to crystallize his own knowledge and make it easily understood has produced a book easily read and of value to physicians and orthopaedic specialists as well.

MASSAGE AND THERAPEUTIC EXERCISE. By Mary McMillan. Ed. 3. Philadelphia, W. B. Saunders Company, 1932. $2.75.

In the third edition of this book, Miss McMillan has given a helpful guide to the student as well as to the practitioner of physiotherapy. She has recognized the constantly accumulating medical information which must be considered in dealing with those affections to which physiotherapy is applied, and has rewritten two chapters and added much to the text of the previous edition. To understand the basic principles of physiotherapy and their application is essential, and the first portion of the book which deals with this part of the subject should be studied. The various forms of massage are described in detail, and illustrated by photographs and drawings, and their practical application to the different parts of the body and to the joints is given consideration. An instructive chapter is devoted to the description of the different movements of the joints, which should always be taken into consideration in the application of massage and physiotherapy. The chapters on the foot and on scoliosis contain descriptions of many exercises, the value of which has evidently been proved by practical experience. The exercises are illustrated by excellent line drawings and their application to the different curves are indicated.

Throughout the book much has been added from the recent accumulation of knowledge and from the author's constantly increasing experience in this special therapy. Each chapter is well illustrated and the book is to be recommended for all who are particularly interested in massage and the different forms of physiotherapy.

POLIOMYELITIS. Baltimore, The Williams & Wilkins Company, 1932. $6.00.

This work is the end result of a survey made possible by a grant from the International Committee for the Study of Infantile Paralysis, organized by Jeremiah Milbank. The book covers the entire available literature on the subject of poliomyelitis and has been carefully classified, so that all of the subject matter may be relied upon to maintain a high degree of accuracy.

A summary of the historical aspect of poliomyelitis is given, beginning with Heine's Monograph in 1840 and continuing to the present time.

The etiology of the disease is next considered with special reference to the earlier bacteriological theories. The nature of the virus and its distribution in the body is discussed at length. The experimental disease, especially in monkeys, and the various tests and peculiarities of the disease in monkeys is explained.

A careful survey of the literature on resistance and immunity is followed by a thorough and complete discussion of the symptomatology.

The chapter on treatment covers all of the accepted measures and is filled with much excellent statistical material on the results of the various types of treatment. This chapter deals entirely with the treatment of the acute stage except for a small section on a description of the respirator. The treatment after the end of the acute stage is very briefly outlined and covers about one page.

The pathology is given in great detail and there are, in this chapter, many plates showing the microscopic findings in the various parts of the cord and brain.

The final chapter, which is by far the longest chapter in the book, is a consideration of the epidemiology of the disease. This is very completely worked out and contains references to work as late as the fall of 1932. There are innumerable statistical tables and a thorough reading of this chapter will prove of great value to all interested in any phase of the disease.

A topical analysis of the book is appended, as well as a bibliography of 843 articles. There is a short addendum giving the results of the administration of normal adult serum in the prophylaxis of poliomyelitis during the 1932 epidemic in the City of Bradford, Pennsylvania.

The committee is to be highly complimented for the great work in bringing together all of this material. It would consume an indefinite amount of time and great labor for any individual to gather a knowledge of the acute stage of poliomyelitis such as can be gained from this book. It should be emphasized, however, that the work does not deal in any way with the orthopaedic phase of the disease. References are given to the standard text-books for this. The book is primarily for pediatricians and internists, but a knowledge of its contents should be acquired by all of those working with poliomyelitis.

MENTAL DEFICIENCY DUE TO BIRTH INJURIES. By Edgar A. Doll, Ph.D., Winthrop M. Phelps, M.D., and Ruth T. Melcher, M.A. New York, The Macmillan Company, 1932. $4.50.

The title of this small volume (289 pages) covers but one aspect of the material contained. It really represents a careful group study of cerebral birth injuries (spastics) with a threefold purpose:

1. To describe birth injury as a clinical category of mental deficiency by enumerating its mental and physical characteristics.
2. To point out the features of the present psychological tests or observations, which are inadequate for subjects in whom both language and motor handicaps are present, and to suggest modifications which will give more satisfactory indications of their actual ability.
3. To observe, by the use of these methods, what mental development accompanies motor development resulting from physical therapy.

For those who regard cerebral birth-injured children with little less than scorn, or, at best, with an attitude of hasty surgical interest, a careful perusal of the sympathetic approach of these investigators, as set forth in the introduction, is recommended. The chapter on etiology is a concise survey of the contemporary literature and is fairly complete.

The mental tests and measurements used apparently show the Stanford Binet as the most workable for children of the class studied.

Dr. Phelps's chapter on physical therapy is of inestimable value and appears both

theoretically and practically sound. It deals with the fundamentals of the subject,—namely, a correct estimate of the types of dyskinesia with a careful differentiation between those due to pyramidal-tract involvement and those which are secondary to extra-pyramidal or basal nuclei lesions. He recognizes, of course, mixed types.

Treatment proceeds from relaxation to gross movements of the proximal joints, the finer coordinated patterns being the last to be established.

This book should be of interest to all workers in the fields of psychiatry, physical therapy, and orthopaedic surgery.

PHYSICAL THERAPY IN INFANTILE PARALYSIS. By Arthur T. Legg, M.D., and Janet B. Merrill. Reprinted from Principles and Practice of Physical Therapy. Hagerstown, Maryland, W. F. Prior Company, Inc., 1932.

In this little book the authors have put into a convenient form for presentation this special treatment of infantile paralysis. Both authors are particularly fitted to give to the medical public the recent information in regard to physical therapy and the best method of its application to this disease. With the increasing prevalence of infantile paralysis such a work has definite value. Many of the important facts with reference to this affection—its etiology, pathology, etc.—are presented in concise form. The disease is considered in four stages. The various forms of physiotherapy to be used are described, and their use for and application to the special body areas in the different stages are considered in detail with clear directions and many tables. It is a valuable work for the physiotherapist and for the physician who wishes to follow the details of treatment in these cases.

DISEASES OF THE SPINAL CORD. By Williams B. Cadwalader, M.D., Professor of Clinical Neurology, University of Pennsylvania Medical School. (With an introduction by William G. Spiller, M.D., Professor of Neurology, University of Pennsylvania Medical School.) Baltimore, The Williams & Wilkins Company, 1932. $5.00.

The well known author of this text-book presents a compact treatise on diseases of the spinal cord.

He prefaces his discussion of the clinical features of disease with several chapters devoted to their elucidation on anatomical and physiological grounds. The first chapter deals briefly with the neuron theory, the second chapter with the grouping and relation of tracts and the blood supply of the cord, the third chapter with reflexes and reflex action, the fourth and fifth with the topographic diagnosis of disease, citing the symptoms resulting from implication of the various tracts, and stressing the rôle of the sympathetic nervous system in relation to pain. The remaining ten chapters consider in a concise and thorough manner the clinical features of cord disorders.

Many of the illustrations are drawn from original sources. The bibliography in itself is well chosen and worthy of reference by the reader. The book is altogether clear and informative.

RADIOLOGIC MAXIMS. By Harold Swanberg, B.Sc., M.D., F.A.C.P. Quincy, Illinois, Radiological Review Publishing Company, 1932. $1.50.

It is always valuable to have the results of experience recorded in concise form, to serve as a guide to those whose experiences have been less or different and who have had less opportunity to formulate their information. In this book the author has gathered under appropriate groupings a very large number of suggestions for guidance in the uses of the x-ray and roentgen therapy, and has put them almost in the form of aphorisms. In addition to his own, he has collected the opinions of surgeons of prominence and experience.

Part I is devoted to the maxims with reference to radiology in general, Part II to

roentgen diagnosis, and Part III to radiation therapy. For all those who employ roentgen therapy this book will be found to contain a great many helpful suggestions and to serve as a reliable guide.

TRATAMENTO CIRURGICO DA TUBERCULOSE OSSEA (Surgical Treatment of Bone Tuberculosis). By Barros Lima, Professor of Orthopaedic Surgery, Faculty of Medicine of Recife, Brazil.

Barros Lima presents a complete review of the different procedures actually in vogue for the surgical treatment of bone tuberculosis. He divides his book into three chapters:

The first chapter is devoted to the surgical methods for the excision of the lesion itself, synovectomy, arthrectomy, intra-articular or extra-articular evacuation, epiphyseal evacuation, resection, and amputation. He makes a critical review of each of these methods, establishing its indication, and he presents clinical histories of his own cases.

The second chapter is devoted to the operations directed toward obtaining a modification of the tissues in which the tuberculous infection is acting, such as, sympathectomy, Robertson Lavalle's operation, Vignard's operation, Maragliano's operation.

The third chapter is undoubtedly the most important one. It is devoted to the surgical procedures leading to fusion of the tuberculous joints, in order to obtain the cure of the lesion by surgical immobilization of the part. The well known techniques of Albee and Hibbs for Pott's disease, and Berard's modification of the former, which the author prefers, and the various techniques for the fusion of tuberculous hip are discussed, and finally a description of the fusion procedures in other joints.

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Twenty-Fifth Annual Report of the Hospital for Joint Diseases. New York, 1931.

Verzeichnis der Ärztekurse im Studienjahre 1932–1933. Kursorganisation der Wiener Medizinischen Fakultät. Vienna, Minerva Wissenschaftliche Buchhandlung Gesellschaft m.b.H., 1932.

Cyphose Dorsal Juvenil. By Dr. Aresky Amorim. Rio de Janeiro, Canton & Reile, 1932.

Acta Radiologica. The Axel Reyn Birthday Book. Stockholm, Sweden, Vol. XIII, Fasc. 3 and 4, 1932.

Journal de Médecine de Bordeaux et du Sud-Ouest. Bordeaux, Vol. CIX, No. 28, October 30, 1932.

The Journal of the Indian Medical Association. Calcutta, Vol. II, Nos. 1 and 2, September and October, 1932.

Bulletin of the National Tuberculosis Association. Vol. XVIII, Nos. 10, 11, and 12, October, November, and December, 1932.

Slovanský Sborník Ortopedický. Brno, Czechoslovakia, Vol. VII, No. 5, 1932.

Norsk Magasin for Laegevidenskapen. Oslo, Norway, Vol. XCIII, Nos. 10, 11, and 12, October, November, and December, 1932.

* Final Report of The Commission on Medical Education. New York, 1932.

BEITRAG ZUR TECHNIK UND ORGANIZATION DER FRÜHEN KLUMPFUSSBEHANDLUNG (The Technique and Organization of the Early Treatment of Club-Foot). Patrik Haglund. *Acta Orthop. Scandinavica*, II, 233, 1932.

To the program outlined in his text-book in 1923, Professor Haglund suggests additions in the early management of congenital club-foot. He stresses the need of beginning vigorous treatment in early infancy and completely overcorrecting the feet at this time if a nearly normal foot is to be obtained. Only by avoiding recurrences can mutilating bone operations be avoided. The early treatment is now undertaken in two stages.

* To be reviewed in a later issue.

At first the foot is brought into slight equinovalgus and maintained in this position by splinting. After the child begins to walk the deformity of the ankle joint is corrected by Achilles tenotomy. For feet with persistent intoeing further treatment is necessary. If the skeleton of the entire lower extremity is twisted inward, a rotation osteotomy of the tibia is indicated. If the deformity is due to incomplete correction of the foot deformity, the latter should be corrected. If paralysis of the peroneals is the complicating factor, it is advisable to balance the muscle power of the foot by early muscle transplantation.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Ein Beitrag zur Kenntnis der "(Pseudo-) Exostosis Dorsalis Articul. Metatarso-Cuneiformis I" und ihrer Entstehung. Knut Bennet and Harry Hinricsson. *Acta Orthop. Scandinavica*, II, 253, 1932.

The condition known colloquially as the "wooden shoe bump," and discussed scientifically as "(pseudo) exostosis dorsalis articul. metatarso-cuneiformis I," comprises two distinct entities. A primary bursitis, often of a bony hardness, arises from pressure of the foot gear and most frequently in cavus feet. A true exostosis may be the result of hypertrophic arthritis, usually in planovalgus feet. A bursitis may be secondary to the exostosis.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

On the Diagnostic and Therapeutic Employment of Novocain Injections in Traumatic Reflex Contractures. Sven Kiaer. *Acta Orthop. Scandinavica*, II, 273, 1932.

In those cases of contracture of the hand following scarring, novocain injection about the scar served a two-fold purpose. The influence of pain and reflex spasm was eliminated and the amount of true structural contracture determined. In addition there was lasting relief from pain, coldness, atrophy, with more or less increased mobility of the affected fingers. Surgical removal of the scar tissue was necessary in one case.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Primary Tumors of the Os Calcis. A Study of Thirty-Two Cases with a Review of the Literature. Bradley L. Coley and George S. Sharp. *Am. J. Cancer*, XVI, 1053, Sept., 1932.

The authors have reviewed the literature of primary tumors of the os calcis, and have studied the material available in the Bone Tumor Department of the Memorial Hospital and in the Bone Sarcoma Registry of the American College of Surgeons, comprising thirty-two cases.

They emphasize the difficulty of establishing the diagnosis, owing to the atypical symptoms and signs, and the atypical roentgenographic appearance of tumors of the smaller bones. Biopsy is necessary in practically all cases, either by aspiration or surgical incision.

The treatment of osteogenic sarcoma is amputation; of endothelial myeloma, radiation; and of giant-cell tumor, especially if early before the cortex of the bone is destroyed, curettage followed by an escharotic.

Tumors of the os calcis are rare; diagnosis is almost invariably late; and the prognosis of malignant tumors is no better than that of similar tumors of other bones.

The report contains detailed case histories including photographs, roentgenograms, and photomicrographs of the five cases in the Memorial Hospital series.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

Radiotherapy for Endothelial Myeloma. Arthor U. Desjardins. *Am. J. Cancer*, XVI, 1121, Sept., 1932.

The author discusses Ewing's tumor with special reference to its radiosensitiveness as of diagnostic significance. He states that such sensitiveness, when appropriate radia-

tion is given, is likely to establish the diagnosis more positively than can histological study, which is notoriously confusing in this field. His report is illustrated with photographs, roentgenograms, and photomicrographs of four representative cases from the total Mayo Clinic series of forty-three cases. The reports include some details of the radiation technique and dosage employed.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

SOLITARY MYELOMA (PLASMACYTOMA) OF THE FEMUR. Report of One Case. Warren G. Harding, 2nd, and Theodore S. Kimball. *Am. J. Cancer*, XVI, 1184, Sept., 1932.

The authors' case presented a tumor of the femur at the level of the lesser trochanter, which had caused a pathological fracture. The roentgenogram suggested the possibility of metastatic malignancy, although no other focus of disease was found elsewhere in the course of complete roentgenographic and postmortem examination. The pathological tissue showed a typical plasmacytoma in the microscopic sections. The paper is illustrated with roentgenograms, photographs of the specimen, and photomicrographs. A table is presented, showing some of the facts in the nine other cases reported in the literature.—*Grantley W. Taylor, M.D., Boston, Massachusetts.*

FRACTURES AND EPIPHYSEAL SEPARATION FRACTURES OF THE ANKLE. A Classification of 332 Cases According to the Mechanism of Their Production. Paul A. Bishop, *Am. J. Roentgenology*, XXVIII, 49, July, 1932.

An interesting and beautifully illustrated paper. The author's summary is the best review.

1. In the interest of a better understanding of the relationship of various fractures of the ankle, a classification based on the mechanism of such fractures is desirable.
2. The classification of Ashhurst and Bromer is suggested and reviewed as the one of greatest practical value.
3. Three hundred consecutive adult cases are subjected to this classification, with illustrations of the main types and their variations.
4. The influence of age on traumatic separation of the distal tibial and fibular epiphyses is discussed.
5. Roentgenograms are found to be of little value in diagnosing such injuries, in the absence of displacement, before the eighth year, due to the absence of visible osseous injury.
6. After the eighth year epiphyseal separation without osseous injury is rare, and after the fifteenth year epiphyseal injuries are rare, fractures being of the adult type.
7. Thirty-two cases of epiphyseal separation fractures are presented. These are considered as fractures of the ankle in which the line of fracture involves some part of the epiphyseal line, and are classified as to mechanism, each type presenting definite and characteristic features similar to the adult groups.—*Edward S. Hatch, M.D., New Orleans, Louisiana.*

ROENTGENOLOGIC MANIFESTATIONS OF GIANT-CELL TUMOR. B. R. Kirklin, and Claude Moore, *Am. J. Roentgenology*, XXVIII, 145, Aug., 1932.

This is a study of 110 cases of giant-cell tumors at the Mayo Clinic from 1909 to 1929. The diagnosis was proven by operation or biopsy in eighty-six cases; in twenty-four cases the clinical and roentgenological data sustained the diagnosis; two types were found.

The first or commonly described variety is a central tumor situated in the end of a long bone; it shows trabeculae and expands, but does not break through the cortex.

In the second type trabeculation is not seen; there is a homogeneous lysis of the affected area, the cortex is expanded and dissolved, and the mass projects into the soft tissues. This type is often mistaken for primary sarcoma or metastatic growth.—*Edward S. Hatch, M.D., New Orleans, Louisiana.*

THE TREATMENT OF GIANT-CELL BONE TUMORS BY ROENTGEN IRRADIATION. George E. Pfahler, and Leo D. Parry, *Am. J. Roentgenology*, XXVIII, 151, Aug., 1932.

The roentgen ray in the treatment of these tumors has been used for twenty-five years. Before this the treatment was surgical.

The technique of the roentgen treatment is discussed and twenty-six cases are reported.

The authors feel that irradiation is definitely superior to surgery in the treatment of giant-cell tumors of bone.—*Edward S. Hatch, M.D., New Orleans, Louisiana.*

GIANT-CELL BONE TUMOR. A Consideration of the Morphology of This Neoplasm, the Response to Surgical and Radiation Therapy, and Report in Detail of Two Apparently Malignant Cases. Carleton B. Peirce, *Am. J. Roentgenology*, XXVIII, 167, Aug., 1932.

This extremely interesting and instructive paper analyzes nineteen cases of giant-cell tumor, two presenting malignant features. Roentgen therapy in repeated doses is considered the best treatment, though surgery is used in some cases. If surgery is used it should not follow x-ray therapy in less than six to eight weeks.—*Edward S. Hatch, M.D., New Orleans, Louisiana.*

HEMANGIOMA OF THE VERTEBRA. Jay Ireland, *Am. J. Roentgenology*, XXVIII, 372, Sept., 1932.

There have been only fourteen cases of hemangioma of the vertebrae reported, including the author's case. His is the second case diagnosed before operation or autopsy; most of the cases are symptomless. The author used radium therapy with success.—*Edward S. Hatch, M.D., New Orleans, Louisiana.*

LE CISTI DELLE OSSA LUNGHE (Cysts of the Long Bones). G. G. Forni, *Arch. di Ortop.*, XLVIII, 1, 1932.

The author presents an extensive review of the subject of cysts of the long bones and reports twenty treated cases. The most suitable classification of bone cysts is one based upon definite pathological processes. This classification, however, would not include a group of cysts of unknown or obscure etiology, such as osteitis fibrosa, osteitis deformans, and osseous dystrophies. Definite classification of these depends upon more accurate knowledge concerning the clinical symptoms, development, roentgen findings, and response to therapy.

In discussing the pathogenesis, the author notes that these cysts occur independently of the conditions of life or environment. A history of trauma to the affected bone was often obtained; nevertheless, the author finds it difficult to evaluate its importance. He reviews the various theories concerning the pathogenesis, including the neoplastic, osteitis fibrosa, osteodystrophy, inflammatory, traumatic, and endocrine theories.

In the differential diagnosis, Forni believes that a pathological fracture, occurring during adolescence, in the absence of other evidences of bone fragility, is practically pathognomonic of bone cyst and becomes more positive if there is a history of absence of or only mild pain and absence of functional disturbance.

After reviewing all the methods of treatment suggested, the author concludes that not all cysts should be explored. Small cysts which cause only mild pain should be kept under observation for evidences of progress or regression. If the cysts increase in size and are complicated by fracture, osteotomy with curettement of the cyst, then suture of the soft parts may be sufficient to promote healing. The intracystic hematoma that forms is a good stimulus to osteogenesis, which becomes even more active if bone fragments from the cortex are introduced into the cavity. Tamponage of the cavity is not advised, since it retards cicatrization and facilitates secondary infection. Fat transplants have not been successful in the author's hands. Large cysts, complicated by one or more

fractures, are best treated by osteotomy and curettage of the cavity, followed by massive bone transplants preferably from the tibia, with molding of the cyst wall about the transplant. The author obtained the best functional and anatomical results by this procedure. If the cyst progresses in spite of this procedure, a segmental resection of the cyst is advised. Although some cysts seem to get well without surgical intervention, these may lead to considerable disability due to shortening or deformity.

Roentgen therapy is based on too few observations and indefinite results to be advised. The author gives a detailed report of his twenty cases accompanied by roentgenograms.—*Peter A. Rosi, M.D., Chicago, Illinois.*

Sul Metatarso Varo Congenito (Congenital Metatarsovarus). S. L. Carnevali, *Arch. di Ortop.*, XLVIII, 181, 1932.

Carnevali reviews the cases of congenital metatarsovarus treated at the Pio Istituto Rachitici of Milan. He differentiates metatarsovarus in which there is an external convexity and an adduction of the metatarsal bones from metatarso-adductus in which there is only an adduction of the metatarsals without deformity of the diaphysis. Both conditions are considered as different stages of the same disease. Metatarso-adductus is in all probability the primary stage, and its apparent rarity and occurrence in very young children tends to substantiate this conception.

The author discusses the various theories concerning the etiology of metatarsovarus. He believes that the older theory of intra-uterine mechanical disturbance is the most acceptable.

Adduction of the anterior part of the foot, with a pronounced external convexity and an exaggerated internal concavity, is the characteristic deformity of metatarsovarus. The plantar surface is usually rotated medially in younger infants, whereas, after the child walks, a more or less pronounced pes cavus develops. There is little change in the position of the calcaneum. Difficulty in walking is often the only symptom. Pain is infrequent.

Roentgenological examination reveals only a few cases in which there is an alteration in the relation or form of the tarsal bones. The most important finding was an alteration of the long axis of the cuneiform to an oblique posterior internal and anterior external position.

The author discusses the proposed methods of treatment of metatarsovarus. In the cases treated at the Pio Istituto Rachitici the best results were obtained by closed manipulations with fixation in plaster-of-Paris casts, followed by suitable orthopaedic shoes. When instituted early, this course of treatment offers good results.—*Peter A. Rosi, M.D., Chicago, Illinois.*

Scoliosi con Paraplegia (Scoliosis with Paraplegia). A. Viganò. *Arch. di Ortop.*, XLVIII, 253, 1932.

The author reports a case which he classes as one of the unusual types of severe scoliosis, usually of the congenital type, which may cause no disturbance until adolescence when a spastic paraplegia suddenly develops, with derangement of the sphincters and occasionally severe sensory disturbances. Characteristically this paraplegia comes on without any apparent cause, such as trauma or infection.

The cause of the transverse lesion of the cord is not known but is believed to be due to the disturbances resulting from the abnormal differential growth of the vertebral canal and the spinal cord in the thoracic region, these disturbances, for the most part, being in the blood or lymph vessels. Laminectomy by relieving the pressure or increasing the size of the vertebral canal allows free circulation and recovery, for apparently no actual nerve degeneration takes place for a long time. Only about eighteen cases have been reported in the literature. The authenticity of the author's case depends upon further observation, because laminectomy, although advised, was refused.—*A. Louis Rosi, M.D., Chicago, Illinois.*

RECONSTRUCTION OF FOREARM AFTER LOSS OF RADIUS. H. H. Greenwood. *British J. Surg.*, XX, 58, July, 1932.

In the case described, the loss of a portion of the radius resulted from osteomyelitis. One year later there was marked deformity of the forearm. This deformity was corrected by a very ingenious operation which consisted of first replacing the soft parts by a tubular graft and then using a portion of the ulna to stabilize the lower end of the radius. An oblique osteotomy was done in the ulna, the upper fragment set into a notch made in the isolated lower end of the radius and the lower ulnar fragment united to the shaft of the radius making a Y. This gave a stable wrist joint and allowed the boy to develop normally and later to do laborious manual work.

A NOTE ON THE MOVEMENTS OF THE SHOULDER-JOINT. C. P. Martin. *British J. Surg.*, XX, 61, July, 1932.

Abduction of the arm is a complicated movement consisting of true abduction of the humerus at the humeroscapular joint combined with rotation of the scapula and elevation of the clavicle. The writer believes that it is not recognized that, in addition to these movements, there is also a lateral rotation of the humerus to over ninety degrees. A certain amount takes place during the first half of abduction, but for the most part as the arm is raised from the horizontal to the upright position. This is of importance in shoulder-joint disabilities, for frequently the blame is laid on lack of power to abduct, when in reality the lateral rotation is at fault.

A REPORT ON THE STRANGEWAYS COLLECTION OF RHEUMATOID JOINTS IN THE MUSEUM OF THE ROYAL COLLEGE OF SURGEONS. R. Lawford Knaggs. *British J. Surg.*, XX, 113, July, 1932.

This collection was made by Dr. Strangeways, a pathologist at St. Bartholomew's Hospital, during the years 1905 to 1914. This report is made after a very careful study of all this material. It deals with osteo-arthritis, rheumatoid arthritis, gout, fibrous and bony ankylosis, and Charcot's disease. The clinical and pathological studies are correlated and certain deductions are made from the study. The article is illustrated by excellent photomicrographs.

RADIOGRAPHIC INVESTIGATION OF LUMBAR AND SCIATIC PAIN. James F. Brailsford. *British Med. J.*, II, 827, Nov. 5, 1932.

Brailsford discusses the important value of x-rays in the diagnosis of low back pain. The article deals only with x-ray findings in this disease. Congenital and developmental abnormalities he finds frequently (twenty-five per cent), but of doubtful significance in the explanation of the patient's symptoms. Trauma accounts for many cases of painful back and often the x-ray reveals clear evidence of the disease. He rightly points out that often the disability of which the patient complains is out of all proportion to the x-ray findings. Toxaemia giving rise to local changes, the spine accounts for the largest proportion of cases. X-ray often reveals clear-cut evidence of this type of spinal disease or of the focal infection (*e.g.* dental apical abscess) which has given rise to it. Inflammatory condition and tumors account for a smaller proportion of cases.—*R. I. Harris, M.B., Toronto, Canada.*

CONGENITAL ABSENCE OF HEAD OF FEMUR. Alex Brownlee. *British Med. J.*, II, 835, Nov. 5, 1932.

This is the report of a congenital anomaly of development of the head of the femur occurring in two members of a family with an associated lesion in a third member. Strictly speaking, the cases do not represent absence of the head of the femur, but rather

delayed and abnormal ossification of the upper femoral epiphysis. The result is not unlike Legg's disease but arising congenitally.—*R. I. Harris, M.B., Toronto, Canada.*

REMARKS ON CLINICAL APPLICATIONS OF THE RECENT WORK ON BONE DISEASE. Edward Mellanby. *British Med. J.*, II, 865, Nov. 12, 1932.

Mellanby ably summarizes recent work which has increased our knowledge of bone physiology and bone disease and has permitted more rational treatment. The two lines of investigation which have yielded the greatest knowledge of bone physiology and disease are: (1) the influence of dietetic and environmental factors on bone disease; and (2) the rôle of the parathyroids. Mellanby's paper presents a clear picture of our present knowledge of bone physiology,—rickets, osteomalacia, osteitis fibrosa cystica, Paget's disease of bone, and renal rickets.—*R. I. Harris, M.B., Toronto, Canada.*

ÜBER DIE OSTEOMYELITIS DER WIRBELSÄULE. (Osteomyelitis of the Spine.) S. Lenner, *Bruns' Beitr. z. Klin. Chir.*, CLV, 223, 1932.

Four cases are reported of which two were acute, one was subacute, and one chronic. All were primary cases, occuring in males from twenty to forty years of age. In one acute case and one chronic case the vertebral body was affected, and in the remaining two cases the disease process was located in the spinous process.

The roentgenogram does not reveal any information in the early case. In one instance a mediastinal abscess was noted nine days after the onset of the disease. In later stages it reveals destruction of bone. However the shadows due to new bone formation characteristic of osteomyelitis are not detected for a relatively long period of time after onset. Yet, in spite of that, the histological examination shows an extensive formation of new osteoid tissue which is as yet poorly calcified.

The final proof for the diagnosis is the demonstration of the bacteria, which is usually not possible before operation. The most common agent is the staphylococcus aureus.

Sequestration is not seen either clinically or roentgenographically.

Treatment consists of radical removal of diseased tissues. When the vertebral body is affected, one must be content with drainage of the abscess and immobilization of the spine.—*R. J. Dittrich, M.D., Fort Scott, Kansas.*

ÜBER SPONDYLOLISTHESIS. Hans Schaer. *Bruns' Beitr. z. Klin. Chir.*, CLV, 287, 1932.

Following a review of the literature on spondylolisthesis, the author discusses the controversial views regarding the etiology of this condition, particularly the question of the associated trauma as a causative factor.

Spondylolysthesis is not to be conceived as a maldevelopment due to arrest, which may be explained by the failure of two bone centers to form an osseous union. Rather it represents an obvious maldevelopment in the sense that the presence of two bone centers in one half of the vertebral arch is of itself an anomaly.

In the diagnosis of a spondylolisthesis of the fourth lumbar vertebra it must be noted whether the vertebra which appears to be the fifth lumbar is not in reality a lumbarized sacral vertebra. With this anomaly the slipping occurs, as a rule, between the fifth lumbar and the lumbarized first sacral, because the firm union between this transitional vertebra and the second sacral does not permit a slipping. At first glance, this anomaly may simulate a slipping of the fourth lumbar vertebra.

Similarly, in a spondylolisthesis of the fourth lumbar, we find not infrequently a sacralization of the fifth lumbar vertebra. For the same reason as above, a slipping, if it occurs at all, is much easier between the fourth and fifth lumbar vertebrae than it is between the fifth lumbar and first sacral, because, as a result of the sacralization, the fifth lumbar and the first sacral would be more firmly united than the fourth and fifth lumbar vertebrae.

Spina bifida occulta is such a common anomaly, either with or without spondylolisthesis, that, etiologically, it is not important.

Five case reports are included in this article.—*R. J. Dittrich, M.D., Fort Scott, Kansas.*

DISLOCATION OF THE ASTRAGALUS. S. L. Haas. *California and Western Med.*, XXXVII, 176, Sept., 1932.

The author discusses the frequency of dislocation of the astragaloscaphoid joint, the mechanism of production of the various forms of luxation, and the necessity of x-ray views for diagnosis. To reduce, the foot is flexed plantarward if the head of the talus is displaced downward, and dorsally when the head is luxated upward. Pressure is made upon the head and additional lateral movements may be necessary. The prognosis is favorable, though complications—such as arthritis, necrosis of skin, or gangrene of the foot—may follow.

One case complicated by fractures of the fibula and cuboid is reported.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

DIE ENTSTEHUNGSURSACHE DER PSEUDARTHROSE NACH BRUCH DES KAHNBEINS DER HAND. (Cause of Pseudarthrosis Formation Following Fracture of the Carpal Navicular.) H. Lützeler. *Deutsche Ztschr. f. Chir.*, CCXXXV, 450, 1932.

The analysis of 117 cases of fresh fracture and fourteen cases of pseudarthrosis of the carpal navicular bone, together with anatomical studies of the blood supply of this bone, has led to the following conclusions:

Fracture of the carpal navicular shows a tendency to pseudarthrosis formation only when a smooth transverse fracture occurs through the middle of the body of this bone. This was demonstrated by x-ray examination.

It was shown by injection of blood vessels that the distal and the proximal halves of the navicular are so well supplied with blood vessels that, in case of fracture, it is impossible to have the blood supply cut off from either of the fragments. Each half of the bone has its own vascular system, and the vessels of the two halves anastomose freely, intra-osseously and extra-osseously.

The fracture which has a tendency to pseudarthrosis formation occurs partly in areas which are covered by joint cartilage. This provides for a weakness of the callus which, however, leads to pseudarthrosis formation only in transverse fractures through the middle of the bone, because only in this type of fracture can harmful mechanical influences act on the callus. These harmful influences consist of traction of the tense capsule and ligaments, even when the hand is immobilized, but are more pronounced during movement.

Prolonged immobilization is necessary only in case of a smooth transverse fracture through the middle of the body of this bone. All other fractures heal by bony union, with immobilization for two to three weeks and physiotherapeutic after-treatment.—*R. J. Dittrich, M.D., Fort Scott, Kansas.*

ANATOMIE UND KLINIK DER LUMBOSACRALEN ÜBERGANGSWIRBEL (SAKRALISATION UND LUMBALISATION). [Anatomical and Clinical Study of the Lumbosacral Transition Vertebra (Sacralization and Lumbarization).] Carl Blumensaat und Carl Clasing, *Ergebn. d. Chir. u. Orthop.*, XXV, 1, 1932.

An analysis is made of the anatomical and clinical features of variations in the lumbosacral region. This article contains a very careful and extensive review of the literature on the subject, in addition to the studies made by the authors.

A nerve injury by compression, with sacralization of the fifth lumbar vertbra, is improbable, both from anatomical investigations and on the basis of development.

In the neurological examination of thirty patients such injury could not be demonstrated. In some cases of sacralization, the nearthrosis may be the seat of a deforming arthritis, which is occasionally the cause of complaints. With a high-grade asymmetry of the vertebra, disability results, in exceptional cases, on the basis of a static-dynamic decompensation. Among ninety patients with lumbosacral transitional vertebrae, only three had disability which could reasonably be attributed to the asymmetry.—*R. J. Dittrich, M.D., Fort Scott, Kansas.*

Résultats Éloignés de L'Arthrodèse Extra-Articulaire de la Hanche "Pour Coxalgie" chez l'Adulte. (Extra-Articular Arthrodesis of the Hip for Coxitis in Adults.) A. Contargyris. *La Grèce Médicale*, XXXI, 89, 1932.

The author reports four cases of coxitis in adults, operated on by extra-articular arthrodesis, the results of which were good and permanent for one and one-half years to five years after the operation. In three of the cases the disease was old; in the other it was in the acute stage. The satisfactory result obtained in this latter case with a spontaneous arthrodesis allowed him to consider that extra-articular arthrodesis could be used in this disease on the more active as well as the old cases.

The Treatment of Congenital Clubfeet. J. H. Kite. *J. Am. Med. Assn.*, XCIX, 1156, 1932.

The author's purpose in the following study of over 200 club feet is to determine: first, the efficiency of certain methods of treating these feet as judged by a study of the results and, second, to determine some of the factors that have influenced the treatment.

His series of cases are divided into three groups; the first consists of feet that have been treated by various operative procedures prior to the development of the "non-operative" method. The second group consists of a large group of patients treated by the slow plaster correction method, and the last group consists of patients who had open operations done on the bone structure of the foot.

He notes in his discussion of the operative correction of club feet the danger of gangrene to the feet and toes as a result of stretching the posterior tibial artery too much in the forcible operative corrections. He further notes that correction in boys is longer on the average than it is in girls.—*H. E. Hipps, M.D., Dallas, Texas.*

Problems of Administration in Industrial Surgery. Lloyd Noland. *J. Am. Med. Assn.*, XCIX, 1215, 1932.

Dr. Noland, who is chief surgeon for the Tennessee Coal, Iron, and Railroad Company, gives a comprehensive study of the development of the present efficient medical department of the Company. A number of diagnoses are given, illustrating that under proper light and ventilated working quarters and proper sanitary living quarters, both employer and employee benefit.

It is estimated that from six to seven per cent. of industrial absenteeism is due to accidents, three per cent. to occupational diseases, and ninety per cent. to ordinary sickness.

The labor turnover for the year 1919 was 145.3 per cent. and in 1930 was 5.1 per cent. The Company now requires immunization against typhoid, small pox, and diphtheria.

Employed by the company are fifteen dentists and twenty-five doctors, all on full-time basis. The company maintains, in addition to several field units and a sanitary corps, a base hospital having 310 beds.—*P. M. Girard, M.D., Dallas, Texas.*

Congenital Elevation of Scapula and Paralysis of Serratus Magnus Muscle. Operation. Armitage Whitman. *J. Am. Med. Assn.*, XCIX, 1332, 1932.

The author presents a very ingenious operation for stabilizing the scapula after it has been brought down in the correction of Sprengel's deformity and which likewise may

be used most successfully in cases of paralysis of the serratus anterior. He does not use a rib to anchor the scapula to, as it is a mobile anchorage and is not, therefore, always successful. In his operation the edge of the scapula is anchored to the spinous processes of the dorsal vertebrae. The details are fully described in his paper. He also presents a complication to the operation of correction of Sprengel's deformity that has not hitherto been reported in the literature.

One case of Sprengel's deformity and one case of serratus anterior paralysis, which have been operated upon as long as three years, are presented. Both of these patients now have excellent function.—*H. E. Hipps, M.D., Dallas, Texas.*

L'Ablation Temporaire et la Reposition de la Malléole Péronière dans le Traitement Opératoire de Certain Cals Vicieux du Cou-de-pied (Temporary Removal and Reposition of the External Malleolus in the Operative Treatment of Certain Cases of Malunion at the Ankle). A. Basset. *J. de Chir.*, XXXIX, 487, 1932.

In fractures of the external malleolus which have united with the fragment in poor position and the astragalus displaced either anteriorly or outwardly, the author advises removal of the external malleolus and fixation of the malleolus to the lateral surface of the tibia. The bone is exposed through a curved incision, about eight inches long, which passes downward behind the fibula, and curves forward under the malleolus. If the fracture is fairly recent, the fracture line is separated and the lower fragment is dissected out and removed. If it is old, the shaft of the fibula is cut. The deep surface of the malleolus is then cleared of fibrous tissue and chiseled smooth, and the fibrous tissue and callus are removed from the lateral surface of the tibia and raw bone exposed. The removal of the malleolus exposes the ankle joint and enables the surgeon to replace the astragalus in normal position. If the internal malleolus has been fractured and is displaced, it is exposed by a separate incision and the distal fragment is freed and replaced in its normal position. The loose external malleolus is then fixed to the lower end of the tibia by one or two wood screws and the wound is closed. A plaster cast is left on for about eight weeks. By this operation the author creates a true bimalleolar tibia. He reports three cases with good results.—*J. Albert Key, M.D., St. Louis, Missouri.*

Sur une Voie d' Accès Postérieure de l' Omoplate (Posterior Exposure of the Scapula: Its Application to the Treatment of Fractures of the Neck of the Scapula). R. Dupont et Henri Evrard. *J. de Chir.*, XXXIX, 528, 1932.

The authors describe a posterior incision for the exposure of the neck, mesial border, and body of the scapula. With the patient lying on the face and the affected arm elevated and supported by sand bags, an incision about eight inches long is made along the posterior border of the deltoid. This incision crosses the axillary border of the scapula in its middle third and extends posteriorly to the vertebral border of this bone. The deltoid and latissimus dorsi are separated, and the incision is carried down between the rhomboid major and the rhomboid minor. These muscles are retracted to expose the vertebral border of the scapula and with a periosteal elevator the tissues are elevated from the bone. The scapular origin of the triceps lies in the depths of the wound and protects the circumflex vessels and nerves from injury. Care must be taken not to damage the inferior scapular vessels because, if they are cut, it is difficult to control hemorrhage in the depths of the wound. After the border of the scapula is exposed, the soft tissues are freed from the bone with a periosteal elevator and it is possible to expose the posterior glenoid and the lower half of the anterior border of the glenoid. Likewise, the muscles can be elevated to expose the posterior portion of the neck and body of the scapula. The authors report one case of fracture of the neck of the scapula in which this incision was used with satisfactory results.—*J. Albert Key, M.D., St. Louis, Missouri.*

Sur Quelques Points de Technique dans les Greffes Vertébrales. (Some Points of Technique in Vertebral Grafts.) Y. Picot. *J. de Méd. de Bordeaux*, CIX, No. 7, 196, 1932.

A résumé of some facts on the technique of vertebral bone graft. Dr. Picot speaks of some of the disadvantages of the Albee grafts and prefers the osteoperiosteal grafts buried deeply under the muscles over the laminae of the vertebrae. The points in technique which he suggests are: a long incision parallel to the spinous processes; a thorough exposure of the vertebral laminae by elevation of the attachment of the muscles by a kind of trough made in the laminae to hold the grafts, which is made by a specially devised instrument described by the author. The graft is removed from the tibia, usually the entire face of the tibia, and is divided into two portions to be used on either side of the spinous processes. The grafts are firmly secured in place by catgut sutures. No fixation apparatus is used. Sixteen cases with excellent results are reported.

Un Cas d'Arrachement de l'Épine Tibiale. (A case of Fracture of the Tibial Spine.) Y. Picot. *J. de Méd. de Bordeaux*, CIX, No. 7, 200, 1932.

Dr. Picot reports a case of fracture of the tibial spine with subsequent swelling, hydrarthrosis, and thickening of the capsule, which had been considered and treated as tuberculosis because of these symptoms. The patient was a girl of sixteen years and the accident had taken place a year previously. The roentgenograms, taken at the time, showed a slight amount of atrophy with a small erosion in the region of the center of the tibial area, without any actual foreign body. The lateral view, taken three months later, showed very clearly a small foreign body which represented the fractured tibial spine. This foreign body was later removed. The case was reported to emphasize the need of recognizing the development of joint symptoms, following trauma to the knee, which are frequently mistaken for tuberculosis, and also the need of a sufficient number of roentgenograms to determine the presence of a foreign body.

Anterior Poliomyelitis, with Special Reference to Patients Passed Through the Royal Alexandria Hospital for Children in Recent Epidemics. J. Steigrad. *Med. J. Australia*, I, 785, June 4, 1932.

The observations are from 250 acute cases during the past four years. The age incidence was largest in children from one to four years old with ten cases under one year.

The symptoms most frequently observed were drowsiness or irritability (in nearly every case) and, in over fifty per cent., fever, vomiting, spine sign, and neck rigidity. The spine sign is probably present in over seventy per cent. of early cases and consists of the production of pain on flexing the spine. Amos's sign or the "tripod sign" consists of placing the hands on bed behind the buttocks, when the patient is required to sit up; the two arms and the trunk forming a tripod. This sign is frequently seen in older children.

Lack of uniformity of the deep reflexes is very suggestive. Some cases commence with convulsions, stupor, or unconsciousness; the tendency of this type is toward complete recovery. The author considers the cerebrospinal fluid cell count of extreme value, the average count in his cases being eighty cells per cubic centimeter.

The prognosis is moderately good, more than half of the cases recovering completely. In the bulbar and pontine form those with involvement of the vital centers usually die, while those with the facial paralyses recover. In the cerebral, cerebellar, and meningitic forms the prognosis is good.

The author recognized the following forms:

The abortive; spinal (the most common form); bulbar and pontine, involving muscles in the brain stem; cerebral, with convulsions, aberrations of speech, choreic and athetoid movements, etc.; cerebellar, with marked incoordination; and the ascending and descending form, or Landry's paralysis.

In the treatment, convalescent serum was used freely, but the author withholds judgment as to its value, although very optimistic as to its probable usefulness when its technique is completely worked out.—*Edward N. Reed, M.D., Santa Monica, California.*

ANTERIOR DISLOCATION AND SUBLUXATION OF THE ASTRAGALUS. A. J. Sheftel. *Orthopaedia i Travmatologia.* V, 11, 1931.

Dislocations of the astragalus are rare. The author has not found any references to dislocation or subluxation of the astragalus in the entire Russian orthopaedic literature between 1914 and 1926. The author produced experimentally different degrees of astragalus dislocation on cadavera. For mild subluxations a tear of the capsule is sufficient; a complete dislocation requires a complete destruction of the anterior and posterior lateral ligaments, the severance of the extensor tendons and the astragalocalcaneal, astragalonavicular and astragalocrural ligaments. The x-rays of the author's specimens did not reveal the actual relationship of the experimentally displaced bones. The author believes that subluxations are more frequent than dislocations; subluxations are frequently mistaken for fractures about the ankle joint. X-ray diagnosis of the partial anterior displacement of the astragalus may lead to errors in interpretation and a study in three directions is therefore necessary. The author reports a case and further describes the typical position of the foot with anterior subluxation of the astragalus.—*Emanuel Kaplan, M.D., New York, N. Y.*

NEW INTERPRETATION OF THE PATHOGENESIS AND SURGERY OF PAIN IN CALCANEAL SPUR. L. A. Shilnikov. *Orthopaedia i Travmatologia.* VI, 111, 1931.

Many experimental and clinical facts established at the Institute of Surgical Neuropathology, as well as elsewhere, lead to a definite relationship between neuromata and neuritis, and osteoporotic changes and bones. The calcaneal spur is a result of a neurotrophic disturbance of certain branches of the sciatic nerve, producing a decalcification of the os calcis. The muscle pull on the softened osseous structures of the os calcis creates a subplantar or achillean spur. This spur is a soft decalcinated structure. Calcaneodynia in the presence of a calcaneal spur is an expression of a neuritis and is not produced by the spur. Thus, there are spurs not accompanied by pain and, vice versa, pain in the heel is very often not coexistant with a spur. It was found by the author that a neuritis of the nervus cutaneous surae medialis and nervus suralis are responsible for the calcaneal-spur syndrome. After a neurotomy of one of these branches, the usually soft spur shows more calcification and becomes eburnated; the calcaneodynia disappears. The author had eight cases of neurotomy for calcaneodynia in which there was a 100 per cent. improvement after a period of from four to forty-nine months. Achillodynia is not improved by neurotomy of the above mentioned nerves. The surgical removal of calcaneal spur, which frequently aggravates the calcaneodynia, should be discontinued and replaced by the much simpler neurotomy of the nervus suralis or nervus cutaneous surae medialis.—*Emanuel Kaplan, M.D., New York, N. Y.*

DE LA VALEUR THÉRAPEUTIQUE DES INFILTRATIONS PÉRI-ARTICULAIRES À LA NOVOCAÏNE DANS LES ENTORSES ET LES ARTHRITES TRAUMATIQUES. René Leriche et René Fontaine. *Presse Méd.*, XL, 280, 1932.

The authors inject a one per cent. solution of novocain into the periarticular tissues of the affected shoulder, sometimes daily, sometimes less frequently. The ability to abduct the arm voluntarily returns as soon as anaesthesia is established, but again disappears. After the injections have been repeated at daily (or less frequent) intervals, painless abduction finally supervenes.

Only three cases are reported, all with the diagnosis of traumatic arthritis including two of recent origin.

The method would seem equally promising in the condition we Americans call periarthritis of the shoulder. The authors suggest the use of this method in after-treatment of fractures involving the shoulder joint.

The ability and prominence of the authors combined with the simplicity and safety of the procedure would seem to recommend a trial.—*Emil S. Geist, M.D., Minneapolis, Minnesota.*

MALADIES OSSEUSES ET TROUBLES DU MÉTABOLISME CALCIQUE. P. Delmas-Marsalet. *Presse Méd.*, XL, 282, 1932.

This seems to be an important contribution. It is a report of the cure of a case of Paget's disease and another of von Recklinghausen's disease. These cases are fully reported and adequately illustrated by roentgenograms.

In the latter disease the authors recommend trial of their conservative drug treatment before resorting to a parathyroidectomy. In cases of this type the authors recommend a trial of the following treatment to be used for a period of at least six months' duration:

First, vitamin D dissolved in oil; the daily portion being 7500 units; this amount to be divided and taken in cold milk in two daily doses. Second, three teaspoonfuls of calcium gluconate daily (about twelve grams).

Three times during each week an intramuscular injection of one grain of calcium gluconate in a ten per cent. solution.

Control roentgenograms every three months.

The authors suggest administration of this therapy in osteomalacia and leontiasis ossea.—*Emil S. Geist, M.D., Minneapolis, Minnesota.*

LES HALLUX VALGUS. Hallux Valgus de Posture et Hallux Valgus Inflammatoire. Mathieu-Pierre Weil et J. Delarue. *Presse Méd.*, XL, 586, 1932.

The authors distinguish between postural hallux valgus and that of the arthritic type. There are convincing illustrations. The problem is considered from the viewpoint of the anatomo-pathologist.—*Emil S. Geist, M.D., Minneapolis, Minnesota.*

LES FORMES FRUSTES DE LA COXA-VARA DES ADOLESCENTS. F. Pouzet. *Presse Méd.*, XL, 1352, Sept. 3, 1932.

A report of six cases of what we are now in the habit of calling "slipped epiphysis". In addition to the usual abduction treatment the author calls attention to the necessity of internal therapeusis in cases of this category (endocrines, calcifiants, irradiated sterols).—*Emil S. Geist, M.D., Minneapolis, Minnesota.*

L'APPAREIL OUATÉ DE DUJARIER DANS LES FRACTURES DE L'HUMÉRUS. Georges Rouhier et Pierre Labignette. *Presse Méd.*, XL, 1418, Sept. 17, 1932.

A rather simple and ingenious method for obtaining fixation in fractures of the humeral shaft. The authors use a voluminous amount of absorbent cotton and muslin bandages and nothing else. When properly applied this makes a firm and adequate splint. The method is based on the same principle as that described by Schanz of Dresden in using the same materials in splinting the neck.—*Emil S. Geist, M.D., Minneapolis, Minnesota.*

PECULIAR REGENERATION OF BONE, FOLLOWING MAGGOT TREATMENT OF OSTEOMYELITIS. M. M. Pomeranz. *Radiology*, XIX, 212, Oct., 1932.

The healing process in osteomyelitic bone following maggot therapy is typical and presents three stages:

First, an exudative stage, noted seven to ten days after saucerization, an osteoplastic process. Material approximating the density, but lacking the homogeneity of callus, filling the excavated zone and extending into the overlying soft tissues.

After two to four weeks the second or contractile stage begins. In this stage the callus-like mass contracts down, to reestablish the approximate caliber of the shaft, and becomes as dense as the bone itself. At this time there is no differentiation between medulla and cortex.

The terminal stage is reached about six months after operation, the entire excavated area and contiguous medulla being filled with dense eburnated bone.

The whole process resembles callus formation. The author feels that "it is permissible to conclude that healing is more rapid and that the end product approximates more closely normal bone structure than any of the hitherto accepted methods of treatment".—*Edward N. Reed, M.D., Santa Monica, California.*

La Tarsoclasia Modelante en el Tratamiento de los Pies Bot Varos Equinos Supinados Congénitos Inveterados. José Valls y Carlos E. Ottolenghi. *Revista de Ortopedia y Traumatología* (Buenos Aires), I, 515, April, 1932.

The authors bring up for discussion the question of the selection of treatment for old, inveterate club feet. The German Orthopaedic Society in 1932 and the French Orthopaedic Society in 1931, have had this problem presented in their respective meetings, without arriving at any definite conclusions; two very well opposed tendencies prevailed as had happened in previous meetings. The authors, after a complete review of the different surgical procedures and their criticism, pronounce themselves in favor of osteoclasia, adding, when it seems necessary, tenotomy or lengthening of the tendo achillis, plantar fasciotomy, or subastragaloid arthrodesis. The paper is illustrated with clinical histories, roentgenograms, and photographs of three very interesting cases.—*Alberto Inclan, M.D., Havana, Cuba.*

A Proposito do Tratamento das Fracturas do Antebraço nas Creanças. Barros Lima. *Revista de Ortopedia y Traumatología* (Buenos Aires), I, 495, Apr., 1932.

The author presents the subject of the treatment of fractures of the forearm in children, discussing the advantages of the different procedures recommended for this type of lesion. On account of the pathology found at the site of fracture, the irregular, dentate surface presented by the fragments, and the separation of the periosteum from the ends of the fragments offering great difficulty for the manual reduction of these fractures, Lima recommends the open reduction and apposition of the fragments without any type of internal fixation. In most of his cases the author has decided on the operative procedure, after manual attempt at reduction had failed. In transverse fractures, the existing indentations at the line of fracture are sufficient to maintain the reduction obtained by the open alignment of the fragments; otherwise these indentations can be made by the surgeon in order to obtain the locking of the fragments, as advised by Soresi and Demel. The author presents the clinical histories of thirteen patients treated by him by open reduction and external fixation with plaster splints.—*Alberto Inclan, M.D., Havana, Cuba.*

Viás de Acceso a la Articulación de la Cadera. (Surgical Approaches to the Hip Joint.) Guillermo Allende. *Revista de Ortopedia y Traumatología*, II, 1, July, 1932.

The author presents a very complete study of the matter. A résumé of the history of surgery of the hip joint and the anatomy of the latter is first offered, and a thorough description of the multiple ways of approach to the hip joint follows. The most important part of this paper is the author's experience and advice on the indications for each method, and he presents several of his own cases to illustrate his conclusions. The pos-

terior approach is recommended for all cases of pyogenic infections of the hip in which drainage of the joint is necessary. In all the cases of hip conditions demanding plastic or reconstructive surgery, the anterior or the lateral approaches are advised; in many instances the Smith-Petersen or the Mathieu techniques, combining both ways of approach, are recommended as the best choice.—*Alberto Inclan, M.D., Havana, Cuba.*

LES ARTHRITES CHRONIQUES AMICROBIENNES DE LA HANCHE (Amicrobic Arthritis of the Hip). R. Massart. *Rev. de Chir.*, LI, 162, 1932.

Under this heading the author considers arthritic conditions developing during adult life in hips which were subjected to disease or injury in early life and in those which have not been subjected to previous injury or disease. He first considers the late changes in congenital dislocation of the hip and points out the fact that those hips in which no attempt has been made at reduction and in which a false acetabulum has not developed do not tend to be painful, while those in which anterior transposition has been performed, or in which a false acetabulum has been formed either naturally or by surgical means, as well as a certain percentage of those in which a satisfactory reduction has been obtained, do tend to develop chronic arthritis and tend to become painful. He also notes that subluxation of the hip (coxa valga) is apt to result in chronic arthritic conditions in later life. The same is true of the coxa vara deformities either from rickets or of congenital origin and also of the adolescent coxa vara in which the upper epiphysis of the femur has been displaced. It is interesting to note that he does not consider Legg-Perthes' disease as a frequent cause of arthritis in later life because he believes that this condition occurs so early that the acetabulum becomes adapted to the head of the femur. He cites two cases of unrecognized fracture of the neck of the femur, healed with slight deformity, in which chronic arthritis developed. Finally he takes up the chronic arthritis of the hip which develops during late adult life (morbus coxae senilis) and believes that the primary factor in this condition is a softening of the head of the femur.—*J. Albert Key, M.D., St. Louis, Missouri.*

LES ACCIDENTS NERVEUX DE LA RÉDUCTION DE LA LUXATION CONGÉNITALE DE LA HANCHE. (Nerve Injuries in Reduction of Congenital Dislocations of the Hip.) P. Corret. *Rev. d' Orthop.*, XIX, 5, 1932.

The author reports six cases of peripheral nerve injury and four cases of injury to the central nervous system which occurred in over 2600 reductions of congenital dislocations in Froelich's clinic. He notes that the accident of injury to the sciatic nerve is especially apt to occur in patients from five to nine years old in whom the head is unusually high and in whom the acetabulum is clear-cut with well defined margins. According to Froelich, the impression is that in these cases the head of the femur has never rested in the acetabulum and that they appear to be true embryonic dislocations. There are no postmortem specimens, but dissections of infants indicate that the paralysis of the sciatic is produced in part by hyperflexion and traction and in part by compression of the sciatic nerve between the head of the femur and ischium. The diagnosis is easily made from the foot drop and the vascular dilation of the extremity. The peroneal nerve is more severely injured than is the tibial. Apparently the nerves are not torn and, in most cases, recovery of function occurs in from six months to a year, although cases have been recorded in which the paralysis has been permanent. The cerebral injuries with convulsions and coma are obscure in origin and are thought to result from emboli. The treatment of the peripheral nerve paralysis is conservative. That of the cerebral injuries is also conservative. Two of the four patients with cerebral injuries died.—*J. Albert Key, M.D., St. Louis, Missouri.*

LES PÉRIARTHRITES TRAUMATIQUES. (Traumatic Peri-Arthritis.) R. Pétrignani. *Rev. d'Orthop.*, XIX, 101, 1932.

The author considers those chronic, painful joints which follow an injury in which there was no evidence of damage to the bone nor to the articular surface. He pays particular attention to the knee, and reports eight cases and, when the condition occurs in the knee, he calls it the syndrome of Pellegrini-Stieda. Classically this syndrome may result from a sprain of the internal or external lateral ligament or from a contusion. After the injury the area remains tender and there is a variable amount of disability which may last indefinitely. In the classical cases new bone appears in the region of the injury (generally the origin of the internal lateral ligament into the femur) and may be palpated or seen in the x-ray. The author believes that the condition is primarily a nerve injury which is followed by a hyperaemia with resorption of bone from the epiphysis and deposition of calcium in the oedamatous connective tissue of the capsule. There may or may not be a hematoma and there may or may not be necrosis with connective-tissue proliferation. He believes that the local excess of calcium drawn from the epiphysis as a result of the nerve injury is an important factor and that this leads to calcification and ossification. It is especially common in the shoulder where the calcium is deposited in the subdeltoid bursa. The same condition may occur without the deposition of calcium and the majority of cases are of this type. The condition is differentiated from traumatic arthritis in that the joint surfaces are not involved, although it may be accompanied by traumatic arthritis. The treatment is rest and the author particularly warns against massage which he believes has a tendency to exaggerate the condition. After a period of rest, which is best obtained with an elastic bandage and should be kept up for several weeks if necessary, the author recommends local heat and exercises. Prognosis is good and surgery is rarely indicated. The author recommends blockage of the sympathetic paths to the joint by multiple injections of cocain as advocated by Leriche and thinks that roentgen therapy is strongly indicated in the early cases, but has had no experience with either of the above forms of treatment.—*J. Albert Key, M.D., St. Louis, Missouri.*

BENIGN ANGIOMATOUS TUMORS OF SKELETAL MUSCLES. Hilger P. Jenkins and P. Arthur Delaney. *Surg. Gynec. Obstet.*, LV, 464, Oct., 1932.

The authors present a thorough study of a case of benign angiomatous tumor of the gluteus maximus muscle, and review 256 reported cases, of which sixty-two are summarized.

Ninety-four per cent. of the tumors appear before the age of thirty years; almost half occurred in the first decade. Heredity is not a factor and trauma was present in only seventeen per cent. A congenital factor is possibly of primary importance.

The gross pathology presents three main types: diffuse, circumscribed, or partially circumscribed, the former being the most frequent. The diffuse type often involves other structures than muscles,—as nerves, subcutaneous tissue, periosteum, synovial membrane, large arteries, skin, and large veins.

Microscopically, the most frequent vascular structure was the cavernous space lined by a single layer of endothelium with a thin wall. Arterioles were usually thick-walled with narrow lumen. Thrombi were frequently present. Degenerative changes were advanced in the central part of the tumor.

The most common symptom was a tumor mass, usually slow-growing. Muscles of the extremities were most frequently involved, particularly those of the thigh and leg, though the chest muscles were involved in nearly as many cases. In the large majority of the cases only one muscle was involved. The diagnosis is made on the age of appearance of a slowly developing tumor, the location, pain, some functional impairment or deformity, aspiration of blood and x-ray if phleboliths are present. The differential diagnosis must be made from lipoma, neuroma, fibroma, cold abscess, sarcoma, cysts, and myocytes.

The treatment is local excision. Hemorrhage was a considerable problem in thirty-

eight cases. The prognosis for relief of symptoms is excellent, recurrence in only six per cent. Disability followed in five per cent. No deaths were reported.

Photomicrographs showing the tumor structures are excellent.—*Richard McGovney, M.D., Los Angeles, California.*

Uber Myelom im Kindlichen Altar. (Myeloma During Childhood.) Karl Zäh. *Virchows Arch. f. Path. Anat.*, CCLXXXIII, 310, 1932.

A detailed autopsy report is made of a case of myeloma in a six-year-old boy. The lesions were found in several of the cervical vertebrae, and also in the lungs. Clinically, the course was that of tuberculous spondylitis. Histologically, the condition was a myeloblastic myeloma with occasional masses of erythroblasts. This is the third case on record of typical myeloma in childhood, and the first to be reported in the German literature.

The article contains an extensive bibliography.—*R. J. Dittrich, M.D., Fort Scott, Kansas.*

Ueber Distorsionen der Lendenwirbelsäule bei Sportunfällen. (A Consideration of Traumatic Deformities of the Lumbosacral Vertebrae Resulting from Sport.) J. G. Knoflach. *Wiener Klin. Wchnschr.*, XLV, 136, 1932.

Particular significance is attached to injuries of the spine in view of their frequency, resulting from vocational and traffic accidents. The author, however, contributes this article because of three such injuries occurring during participation in sport. Traumatic deformities frequently occasion severe damage to the vertebral medulla, thus causing vocational handicaps and often endangering life. Such injuries are not recognized excepting through numerous and late examinations following accidents, then being evidenced as a post-traumatic spondylitic lesion, such as is found in Kümmell's disease. These lesions commonly are not demonstrable early by x-ray.

If injuries to the lumbosacral region are only contusions, they are relieved in a short time, and the circumscribed evidences of pathology to the soft tissues overlying same are established. Therefore, because of their relatively short period for recovery, further clinical and x-ray examinations may be excluded.

The three cases of such injury to the lumbosacral spine are described in detail by the author, all having been sustained during participation in sport. The findings in all three subjects are identical. Pain, in all, is most severe in the lumbar spine during movements or attempts at motion.

In the three patients presented, the subjective symptoms did not definitely disappear until after three months, and the patients were able to resume their vocations in from three to five months. After one year the three cases disclosed no symptoms, and the x-ray findings were negative. However, during bending and stretching, there was admitted a feeling of uncertainty in the lumbosacral region. Severe injury to the joint and ligamentous structures of the injured vertebrae caused marked functional loss in the lumbosacral region. This was noted through the complete abandon on the part of the patients.

In the three cases there never was established, during the course of the disease or later, positive clinical or roentgenological findings of a specific lesion, for which trauma could be blamed. Nevertheless, they are considered as correct instances of distortion or dislocation of the lumbar vertebrae. The long duration of the symptoms should rule out simple contusion. Furthermore, the similarity of the symptoms in these cases with those described by Kocher, Henle, and others, under the consideration of cervical dislocations, is the cause for the assumption that the cases cited may be considered as traumatic deformities of the lumbosacral vertebrae resulting from sport.

In this article the etiological, x-ray, and diagnostic findings are very thoroughly discussed and the opinions found in the literature are quoted.—*Alfred J. Buka, Pittsburgh, Pennsylvania.*

Note: We regret that, on account of lack of space, we are unable to publish in full the excellent abstract of this article as prepared by the reviewer. *Editor*